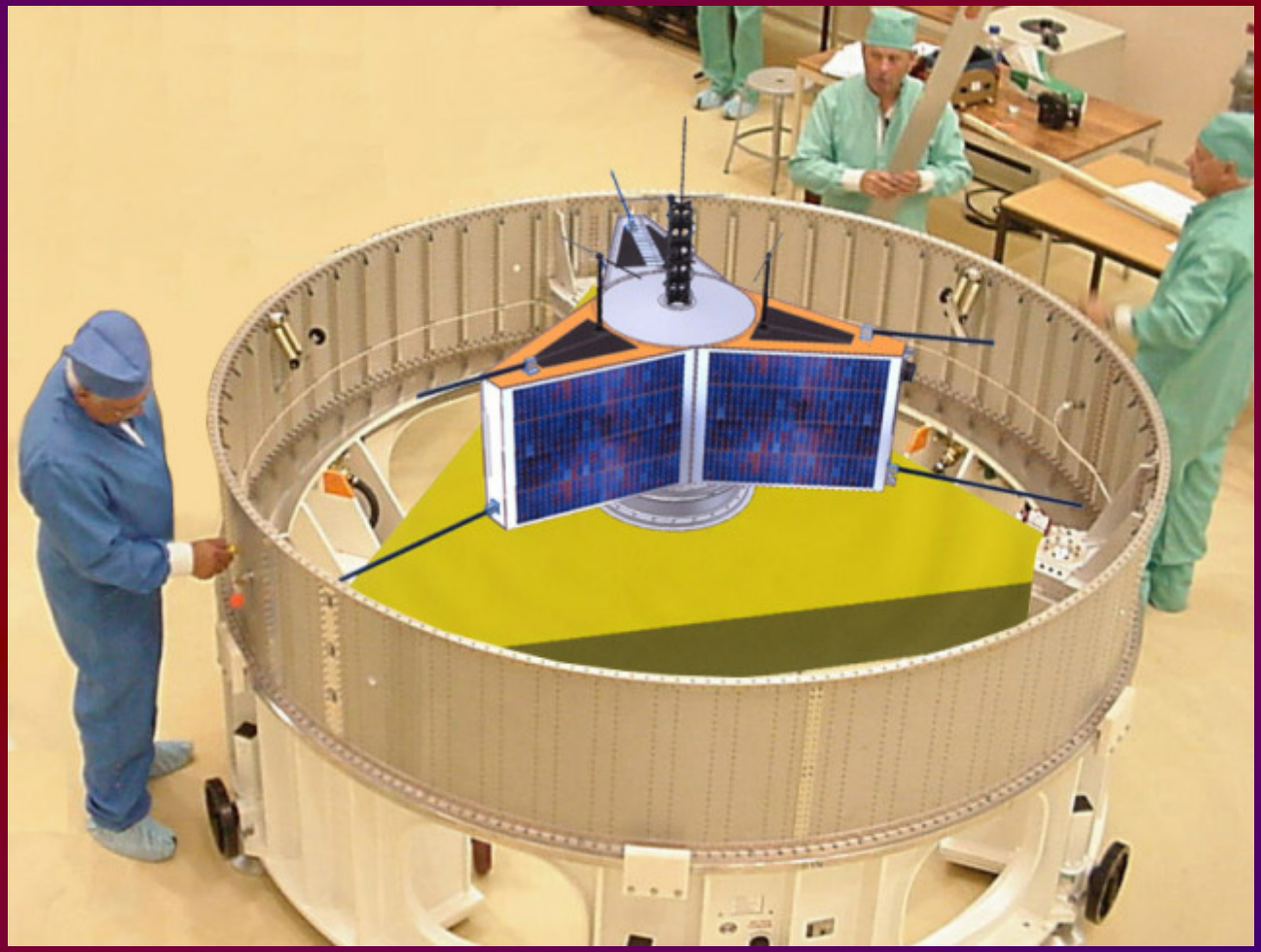
AMSAT-DL

Satellites for Communication and Science
Satelliten für Kommunikation und Wissenschaft

Peter Gülzow, DB2OS
President AMSAT-DL
Project Leader P3-E

Heike Straube
AMSAT-DL Office
Project Manager P3-E

AMSAT P3-E (Phase 3 Express)



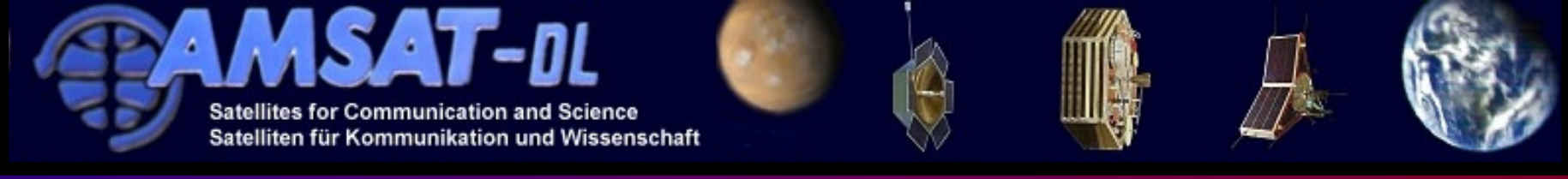
AMSAT P3-E (Phase 3 Express)

Objectives

- *Providing long range and long duration communication performance to amateur radio using a powerful high-performance satellite concept, based on previous Phase 3 satellites.*

- *To test and qualify advanced hardware for P5-A and other future AMSAT spacecraft's.*

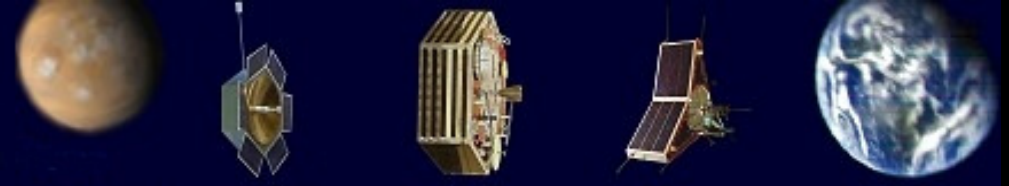
- *No extra qualification (s/c structure, bus, adaptor, propulsion, etc.)*
- *A minimum of resources exist to do the project.*
- *Flight timing compatible with P5-A requirements.*
- *Launch target is 2008*



AMSAT P3-E (Phase 3 Express)

Basic data

Total mass at lift-off ..... 150 kg
Satellite mass in orbit ..... 90 kg
Dimensions ..... Height 50cm / Span 1.30m
Spin stabilized ..... 20 – 40 rpm
Propulsion ..... 220 N engine (Astrium/EADS)
Propellant ..... 25.8 liter MON, 24.7 liter MMH
pressurized by Helium bottle, 2 liter He at 400 bar
Orbit ..... HEO, 2000km perigee, 44000km apogee, 50˚Incl.
Launcher ..... ARIANE-5, French Guiana, Kourou in 2008
..... SOYUZ 2, French Guiana, Kourou in 2009



Power Subsystem

BCR specification similar to P3-A, P3-B and P3-C:

Input current of generator: ..... ≤ 2.7Ampere, P_{max} 92W
Input voltage nominal: ..... 34.32 Volt
Input voltage maximum: ..... 45 Volt

Battery voltage: ..... 14.2 Volt (range 10.36V to 15,46V, 20mV/step)
Solar Generator voltage: ..... 32 Volt (range 19.2V to 44.7V, 100mV/step)

The Battery Charge Regulator (BCR) for P3-E is being designed and built at the University of Budapest (Andras Gschwindt, HA5WH)

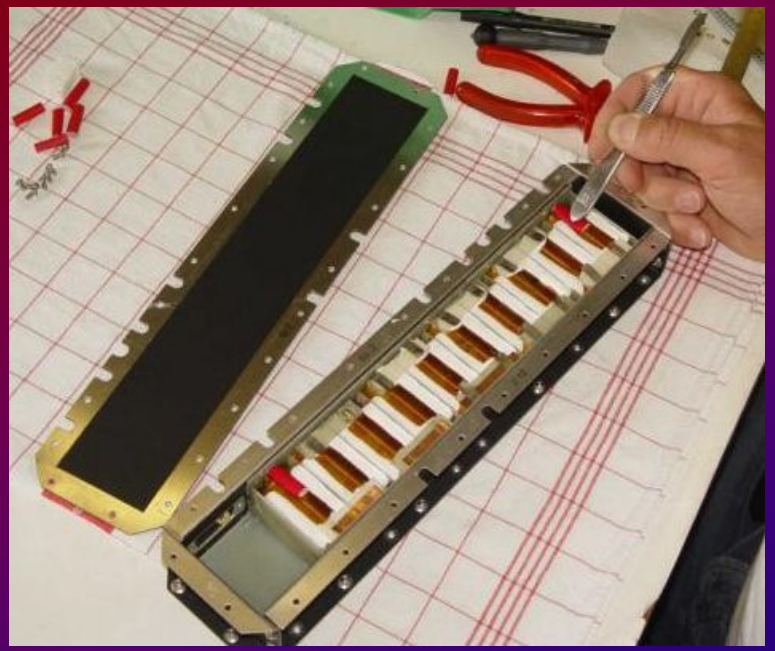
Batteries

Main-Battery

- 10 cells Ni-Mh
- 13 Ah capacity (P3-C was 7 Ah)

AUX-Battery

- 10 cells Ni-Mh (Suppo)
- 4 Ah capacity (P3-C was 4 Ah)



- Batteries were carefully cycled and tested for “matched” cells.
- Main flight battery including Main test battery are already finished.
- Two sets of Aux flight batteries are finished. One set of batteries was donated to AMSAT-DL for KiwiSat.

Solar Generator

Solar cells provided by RWE Solutions
for 2 panels of GaAs (~27% efficieny, P_{max} = 49 W) and 5 panels high efficiency (~13%, P_{max} = 35 W) Si cells.

Assembly of the solar panels by ASTRIUM/EADS (500 µm cover glasses, etc.)

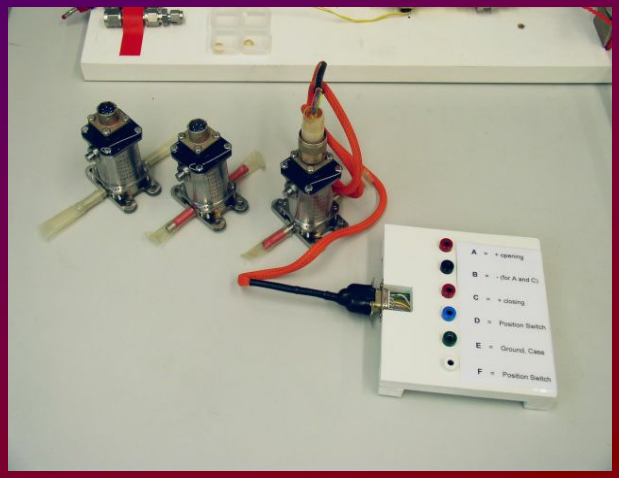
Weight of each panel ~ 5 Kg

Propulsion

Successful qualification of the Helium Tank:

- Burst Test @ 1000 bar => No Degradation
- Destructive Burst @1160 bar => Margin Demonstration

Propulsion



Successful qualification of the High Pressure Section:

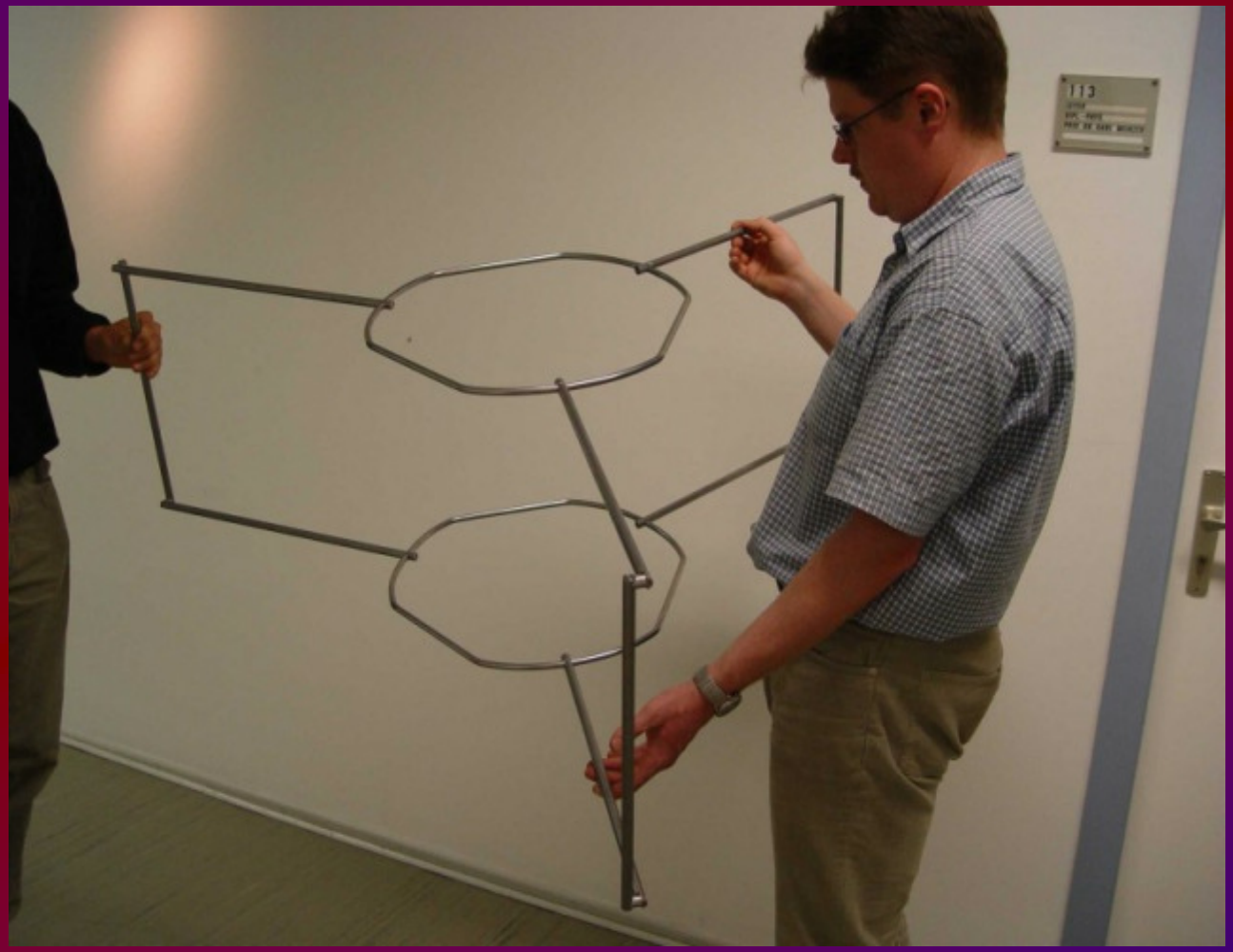
- Endurance Storage + Leakage @ 50 bar (3 Weeks)
- 2 complete Cycles Proof @ 600 bar with mit gas
- Endurance Storage + Leakage @ 400 bar (1 Week)

Qualification test at Astrium

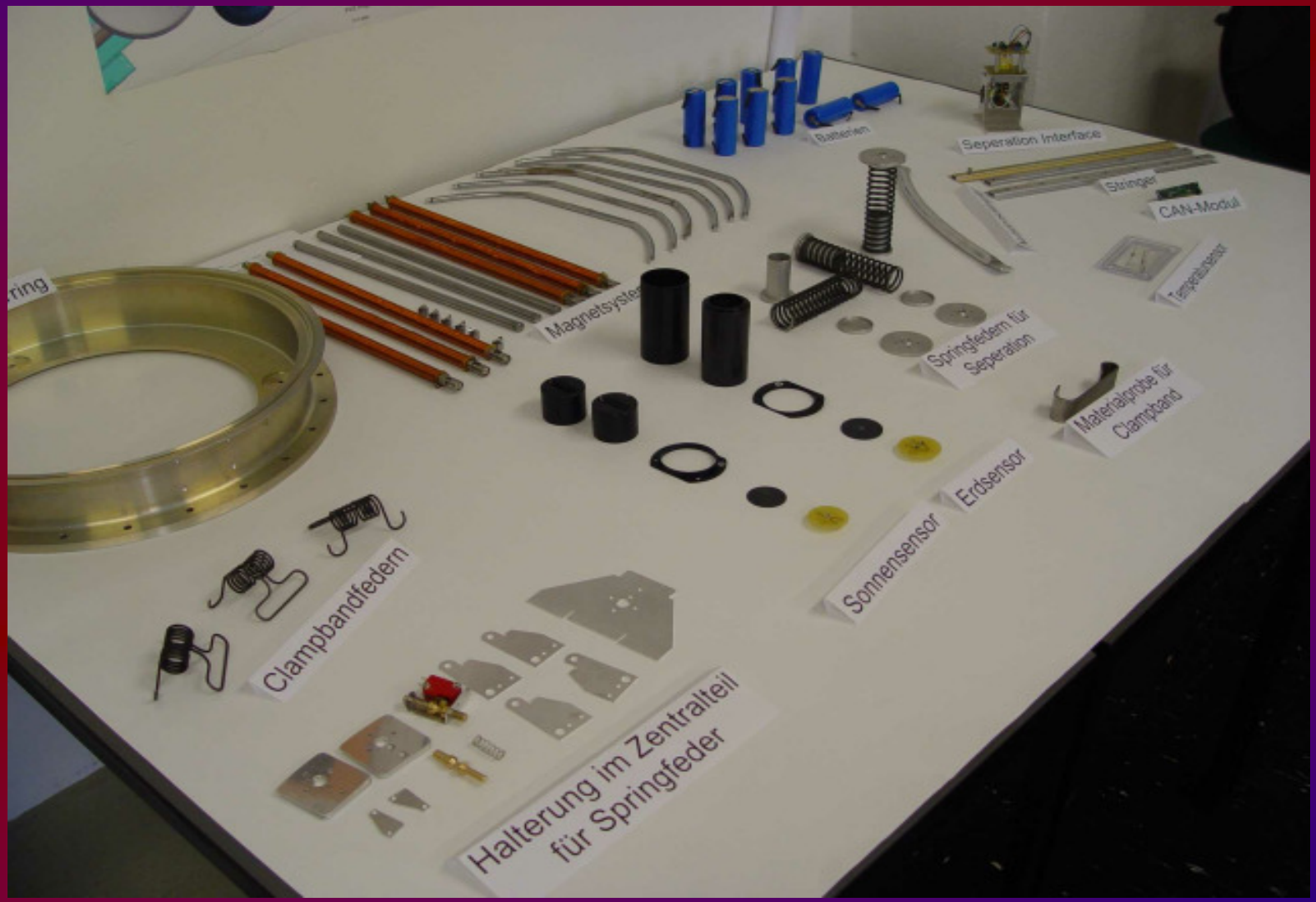
Fully satisfied Propulsion Team

Mounting for the 220 N motor

Magnet System



Misc... all the little parts...

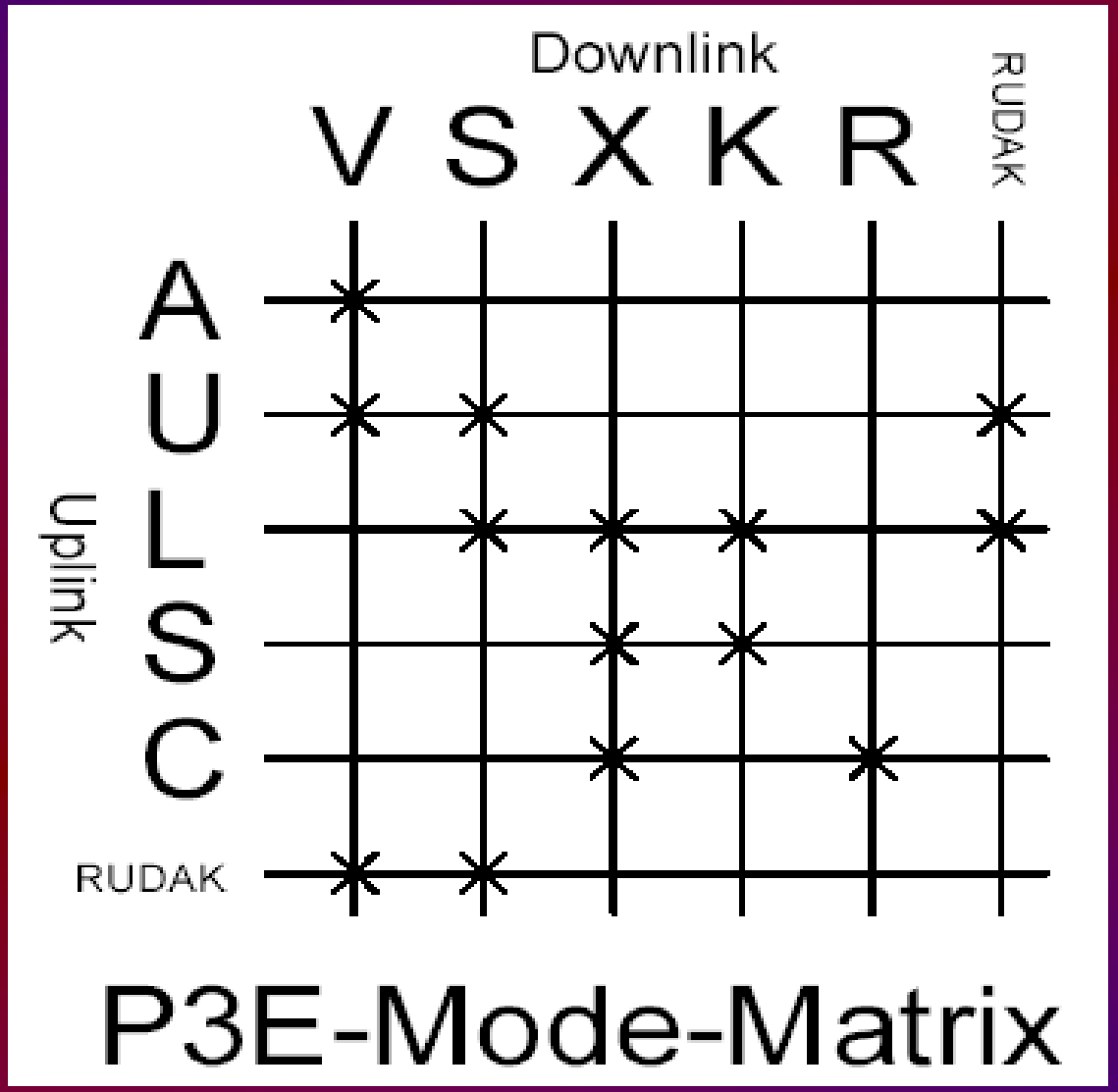


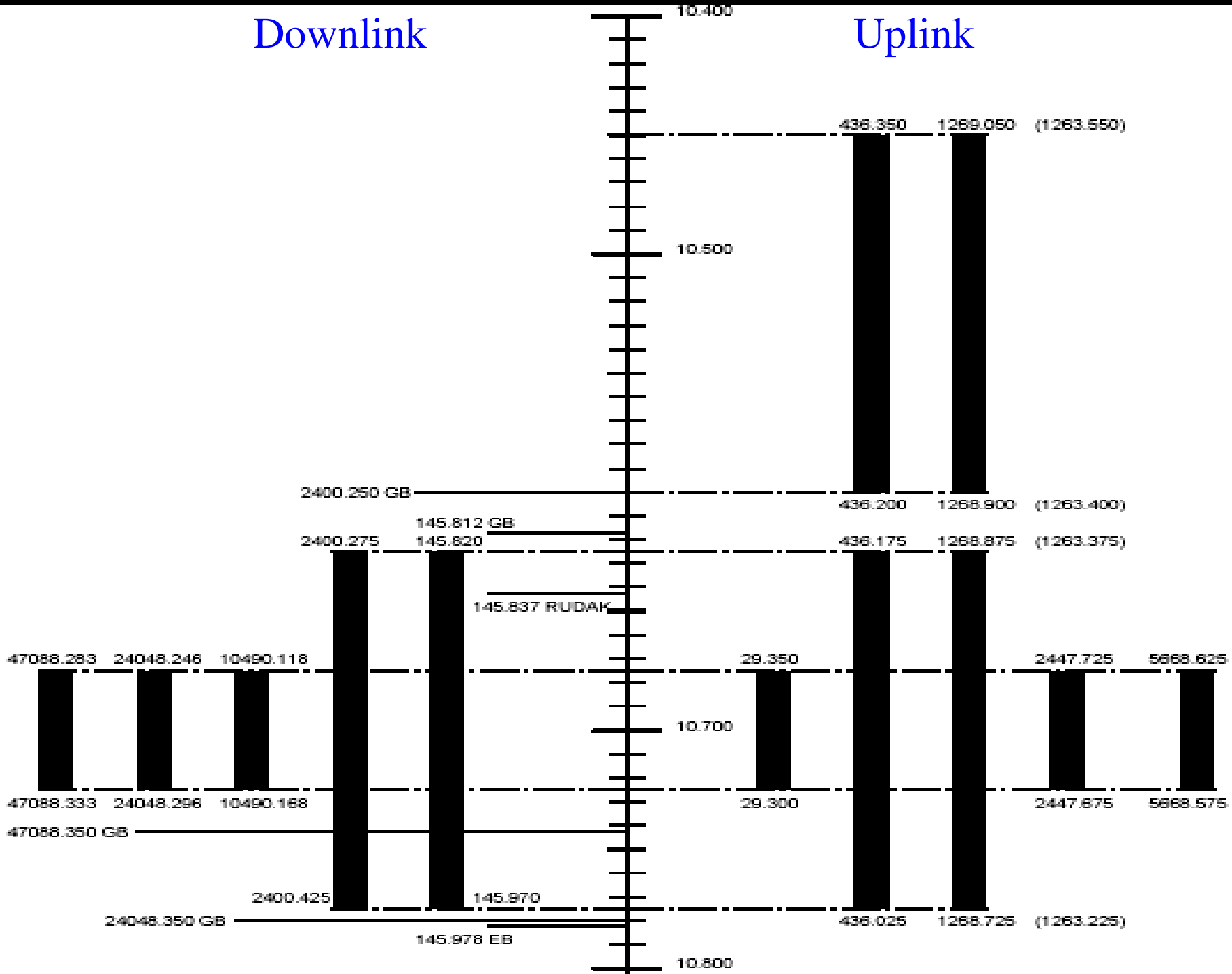
Transponder Payloads

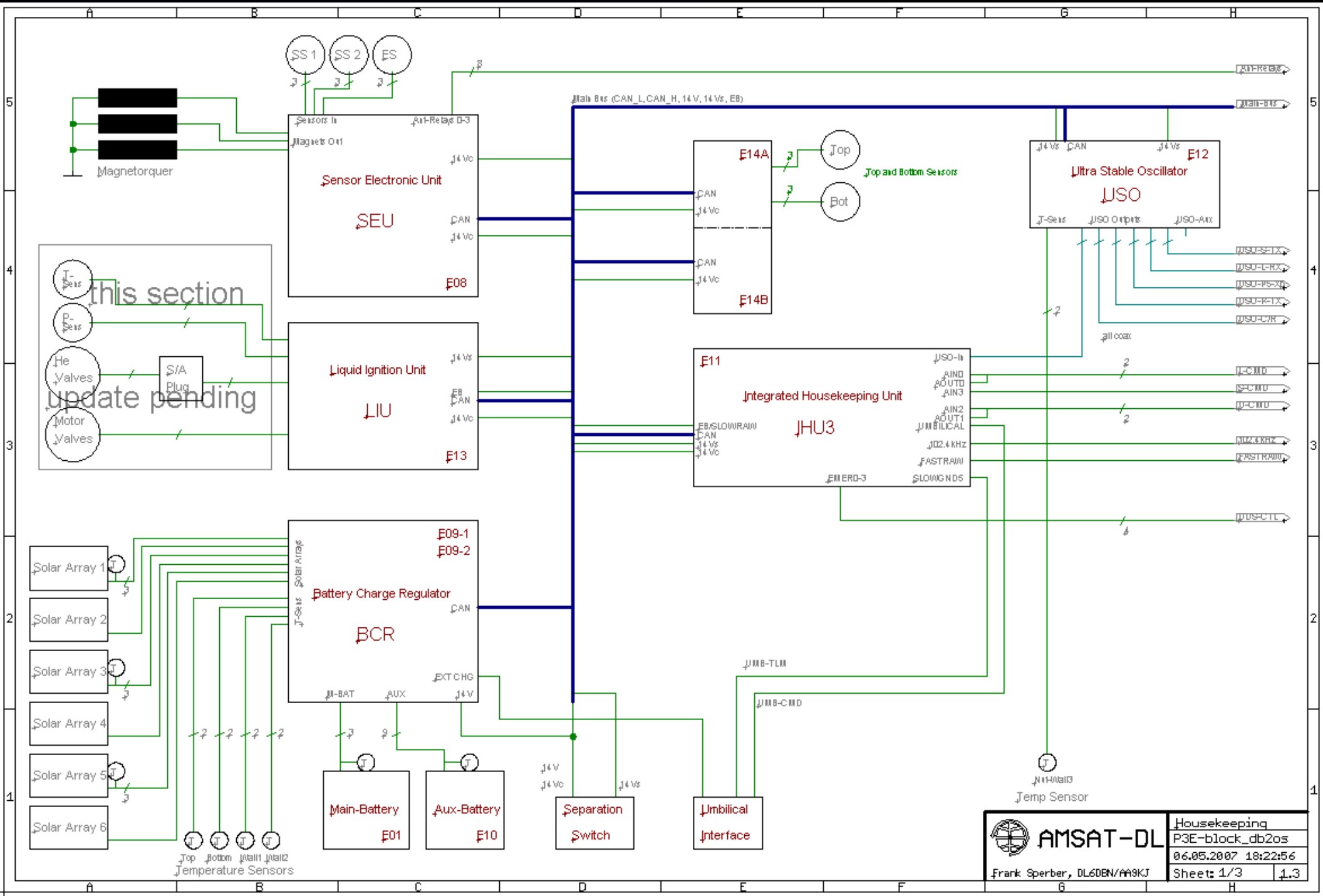
- Mode UV (70cm Uplink, 2m Downlink, max. 60 W_{PEP})
- Mode US (70cm Uplink,. 13cm Downlink, max. 38 W_{PEP})
- Mode LS (23cm Uplink, 13cm Downlink, max. 38 W_{PEP})

- P5-A Transponder (X-Band transmitter)
- Ultra Stable Oscillator (USO)
- C-Rx and S-Rx
- 24 GHz (R-Tx)
- 47 GHz (K-Tx)

- SDX (software defined transponder LEILA, STELLA)


Downlink
V S X K R
RUDAK
A U L S C
Uplink
RUDAK
P3E-Mode-Matrix


Downlink
Uplink
10.400
436.350
1269.050
(1263.550)
10.500
2400.250 GB
436.200
1268.900
(1263.400)
145.812 GB
2400.275
145.620
436.175
1268.875
(1263.375)
145.837 RUDAK
47088.283
24048.246
10490.118
29.350
2447.725
5668.625
10.700
47088.333
24048.296
10490.168
29.300
2447.675
5668.575
47088.350 GB
2400.425
145.970
24048.350 GB
436.025
1268.725
(1263.225)
145.978 EB
10.800


SS 1
SS 2
ES
Magnetorquer
Sensors In
Ant-Relays 0-3
Magnets Ctrl
14 Vs
Sensor Electronic Unit
SEU
CAN
14 Vc
E08
Main Bus (CAN_L, CAN_H, 14 V, 14 Vs, EB)
E14A
Top
Bot
Top and Bottom Sensors
E14B
E12
Ultra Stable Oscillator
USO
T-Sens
USO Outputs
USO-Aux
this section
update pending
T-Sens
P-Sens
He Valves
S/A Plug
Motor Valves
Liquid Ignition Unit
LIU
EB CAN
E13
E11
Integrated Housekeeping Unit
JHU3
USO-In
AIN0
AOUT0
AIN3
AIN2
AOUT1
UMBILICAL
02.4 kHz
FASTRAW
EMERG-3
SLOWGNDS
EB/SLOWRAW
Coax
U-CMD
S-CMD
D-CMD
02.4KHz
FASTRAW
USO-CTL
E09-1
E09-2
Battery Charge Regulator
BCR
Solar Array
T-Sens
EXT CHG
M-BAT
AUX
Solar Array 1
Solar Array 2
Solar Array 3
Solar Array 4
Solar Array 5
Solar Array 6
UMB-TLM
UMB-CMD
Main-Battery
E01
Aux-Battery
E10
Separation Switch
Umbilical Interface
Ant-Wall3
Temp Sensor
Top
Bottom
Wall1
Wall2
Temperature Sensors
AMSAT-DL
Frank Sperber, DL6DBN/AA9KJ
Housekeeping
P3E-block_db2os
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Sheet: 1/3
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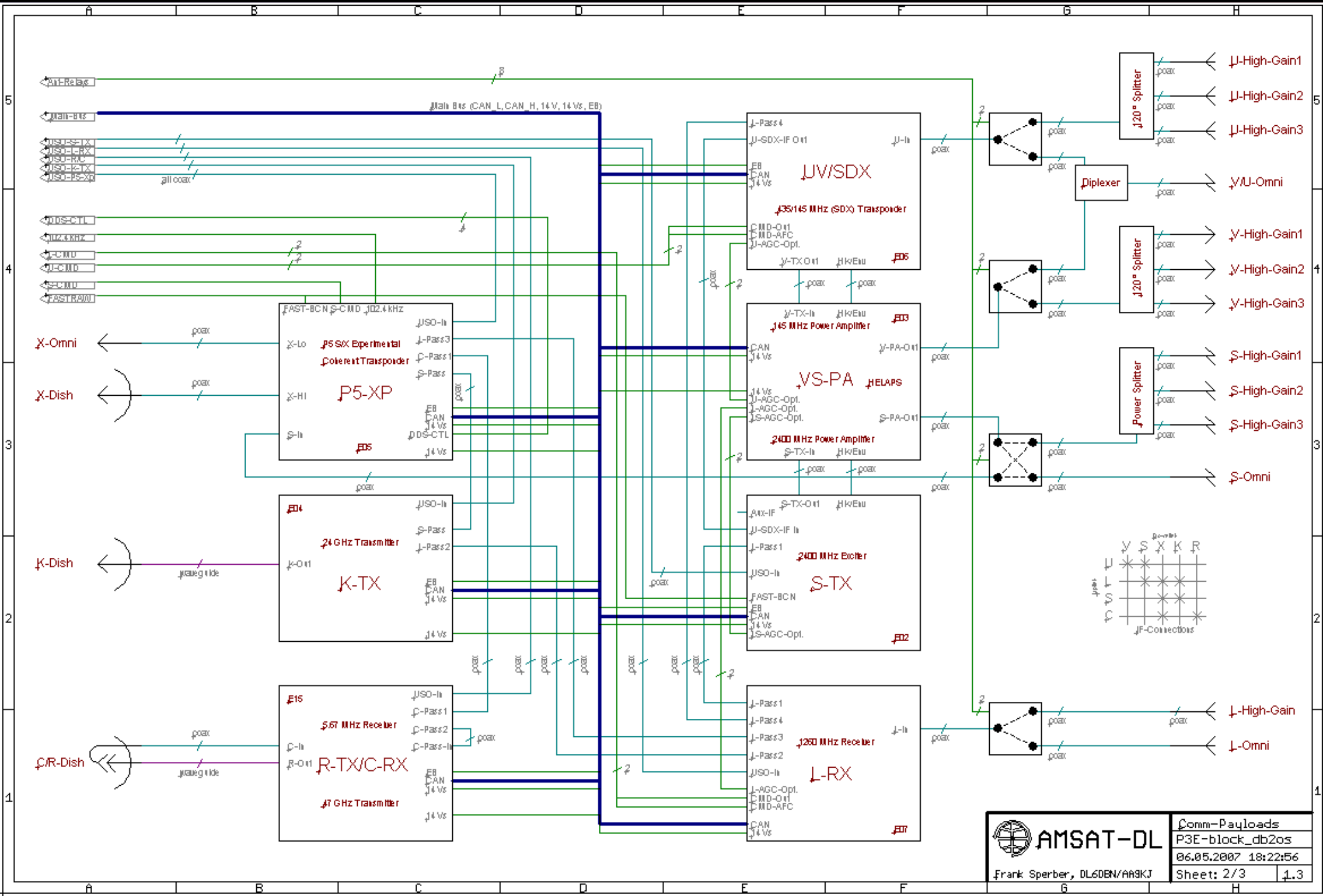
Ant-Relays
Main-Bus
Main Bus (CAN_L,CAN_H, 14 V, 14 Vs, EB)
USO-S-TX
USO-L-RX
USO-RAC
USO-K-TX
USO-P5-XP
all coax
DDS-CTL
102.4 kHz
S-CMD
U-CMD
L-CMD
FAST-BCN
X-Omni
X-Dish
K-Dish
C/R-Dish
X-Lo
X-Hi
S-In
P5-XP
P5 S/X Experimental Coherent Transponder
E05
USO-In
S-Pass3
L-Pass1
S-Pass
DDS-CTL
14 Vs
E04
24 GHz Transmitter
K-Out
K-TX
S-Pass
L-Pass2
waveguide
E15
5.67 MHz Receiver
C-In
R-Out
R-TX/C-RX
7 GHz Transmitter
C-Pass1
C-Pass2
C-Pass-In
L-Pass4
U-SDX-IF Out
U-In
UV/SDX
435/145 MHz (SDX) Transponder
CMD-Out
CMD-AFC
U-AGC-Opt.
V-TX Out
HkEsu
E06
V-TX-In
E03
145 MHz Power Amplifier
V-PA-Out
VS-PA
HELAPS
U-AGC-Opt.
V-AGC-Opt.
S-AGC-Opt.
2400 MHz Power Amplifier
S-PA-Out
S-TX-In
Aux-IF
U-SDX-IF In
L-Pass1
2400 MHz Exciter
S-TX
E02
L-Pass3
1260 MHz Receiver
L-In
L-RX
L-AGC-Opt.
E07
Diplexer
120° Splitter
Power Splitter
U-High-Gain1
U-High-Gain2
U-High-Gain3
V/U-Omni
V-High-Gain1
V-High-Gain2
V-High-Gain3
S-High-Gain1
S-High-Gain2
S-High-Gain3
S-Omni
L-High-Gain
L-Omni
RF-Connections
AMSAT-DL
Frank Sperber, DL6DBN/AA9KJ
Comm-Payloads
P3E-block_db2os
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Sheet: 2/3
1.3

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Transponder Readiness Review
Marburg – April 2007

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V-Band and S-Band HighPower PA

Module E03 by Konrad Hupfer, DJ1EE

Konrad DJ1EE

Parameters:

2m: 3..4 mW Input for 50..60 W PEP Output

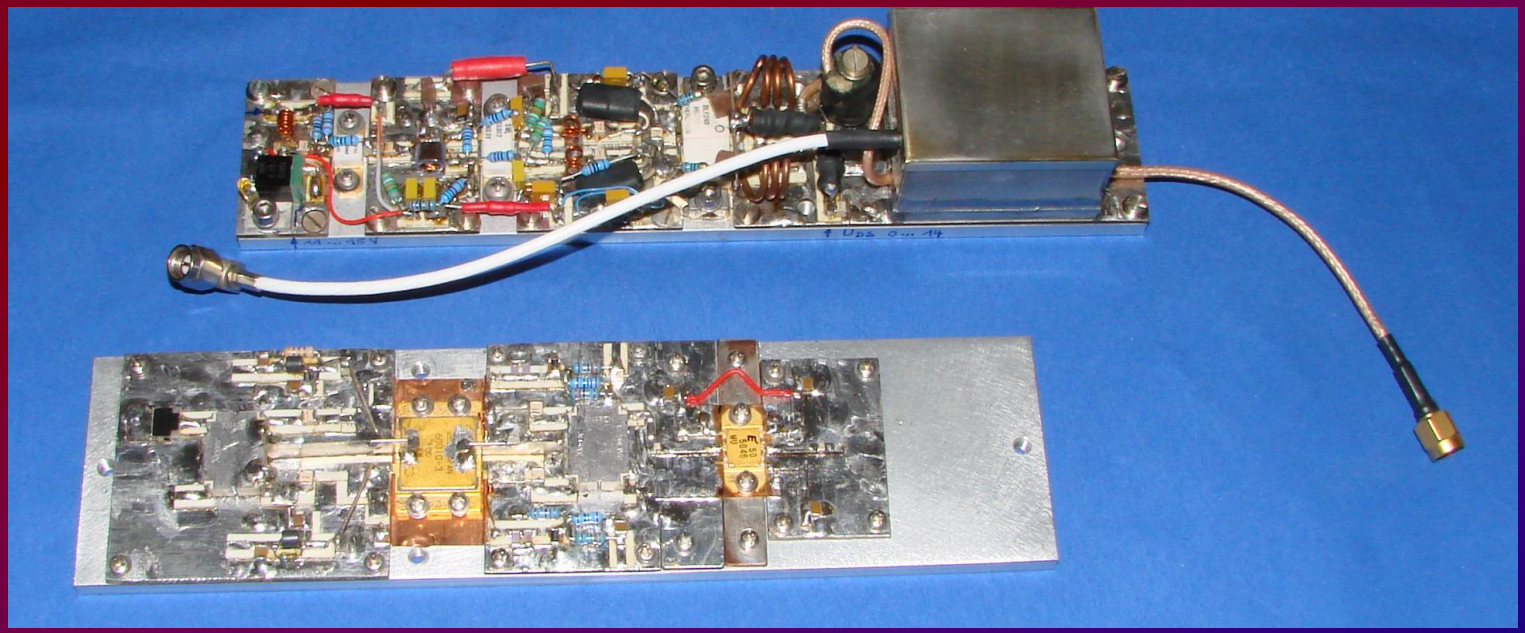
13cm: 5..10 mW Input for 30..40 W PEP Output

Efficiency:

2m: max. 65%

13cm: max. 40%

Will be used with HELAPS



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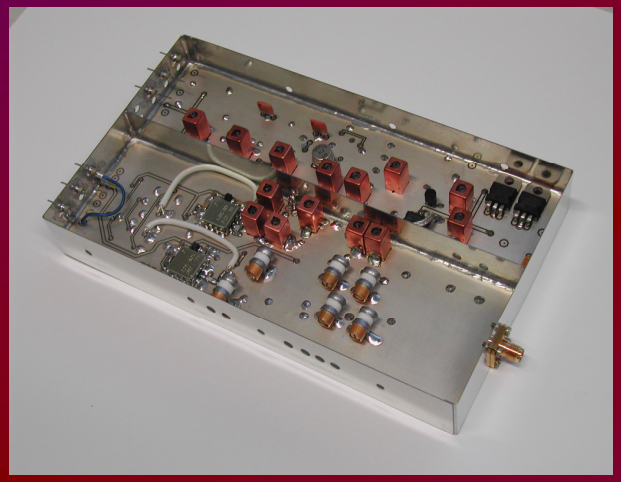
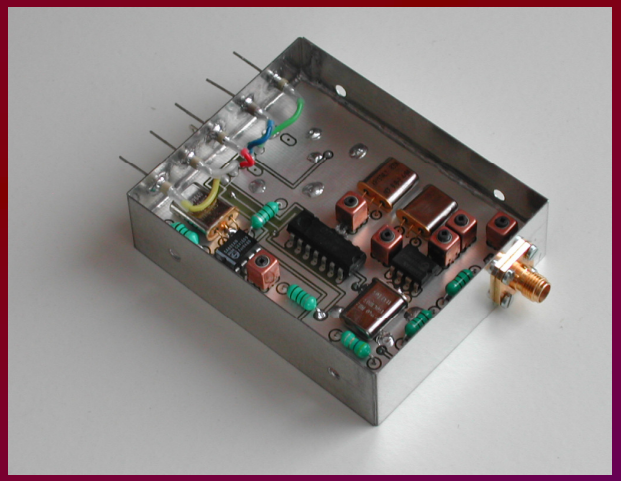
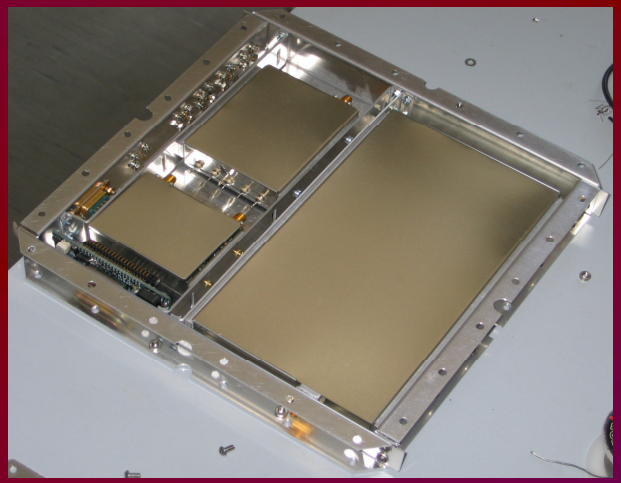
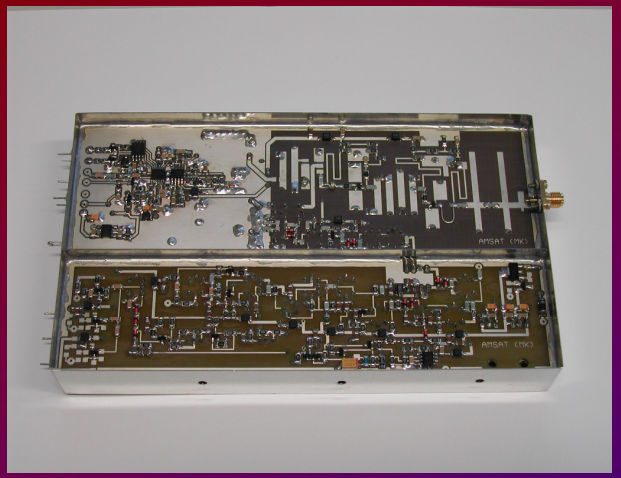
L-Band frontend + Command Detector Module E07 by Mirek Kasal, OK2AQK

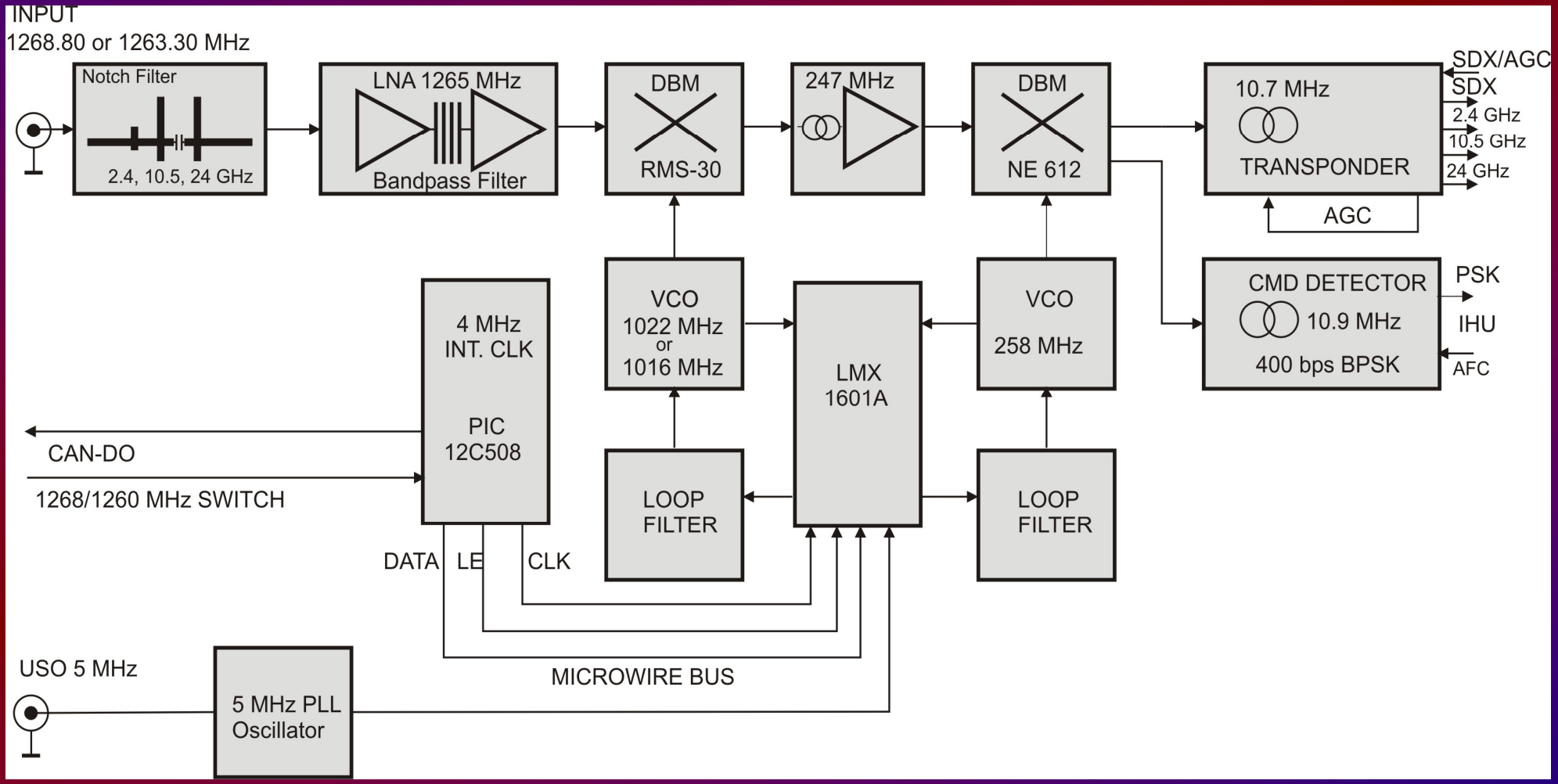








E07 module concept



E07 Performance

RF parameters

• Noise Figure	<0.6 dB
• Gain command detector	95 dB
• Analog passband	150 kHz

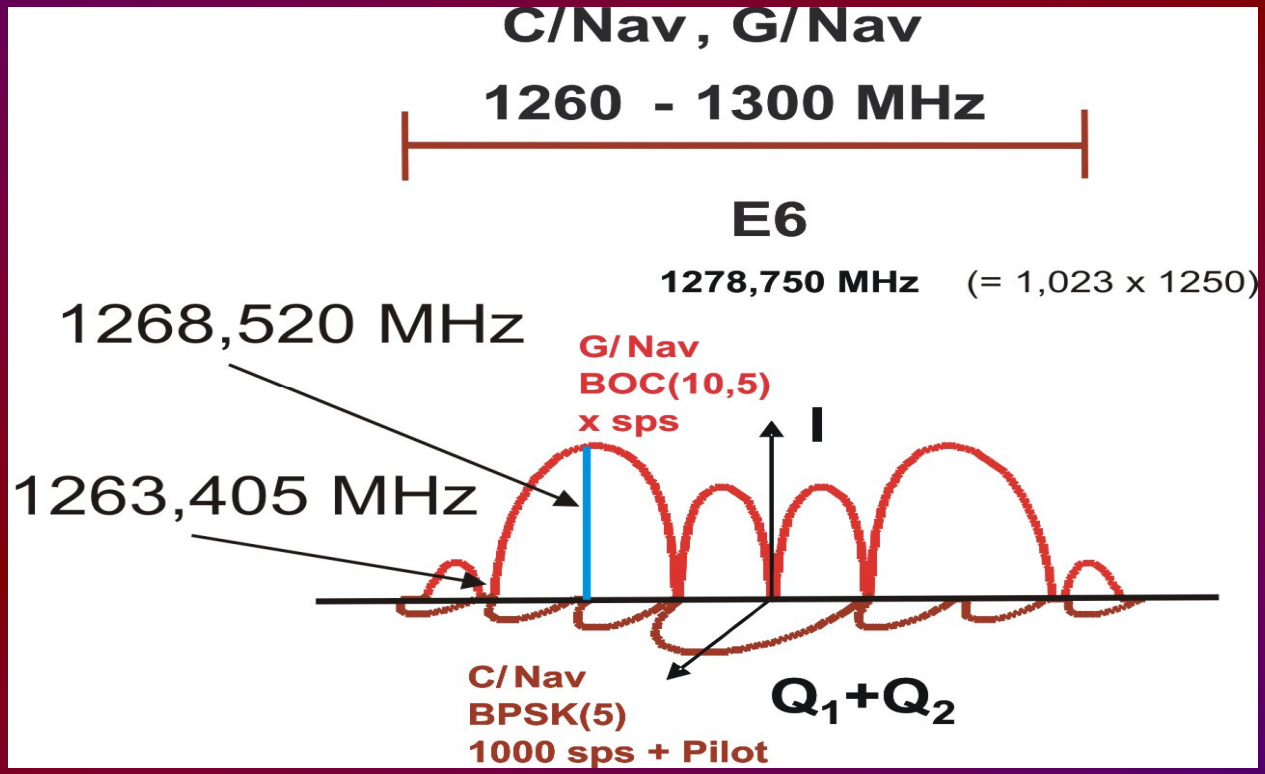
Power consumption

• L-band Front End	1200 mW
• Command detector	420 mW
• 5 MHz PLL Oscillator	280 mW
• **Total**	**1900 mW** (14 V, 136 mA)

Total E07 module mass **1200 g**

L-band RX frequencies & Galileo

The expected minimum power spectral density of the Galileo satellites E6 signal is on frequency 1263,405 MHz



Uplink1 (L1)

```
SDX:          1268.900 to 1269.050 (multi-mode)
Passband:     1268.725 to 1268.875 (linear)
```

Uplink2 (L2 - GALILEO alternative)

```
SDX:          1263.400 to 1263.550 (multi-mode)
Passband:     1263.225 to 1263.375 (linear)
```

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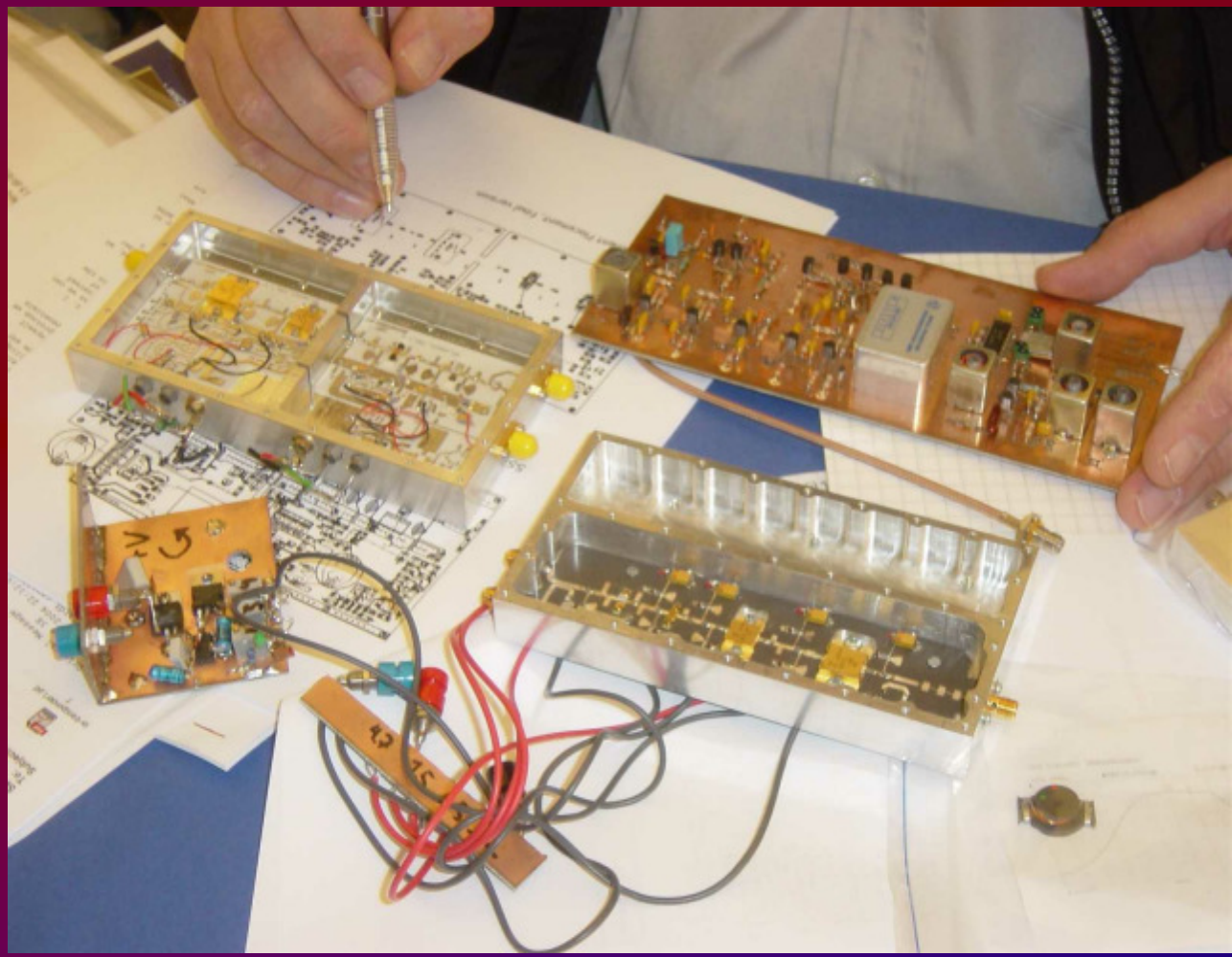
Module E05: P5-A Linear/Coherent X-Band Transponder by AMSAT-OH Team



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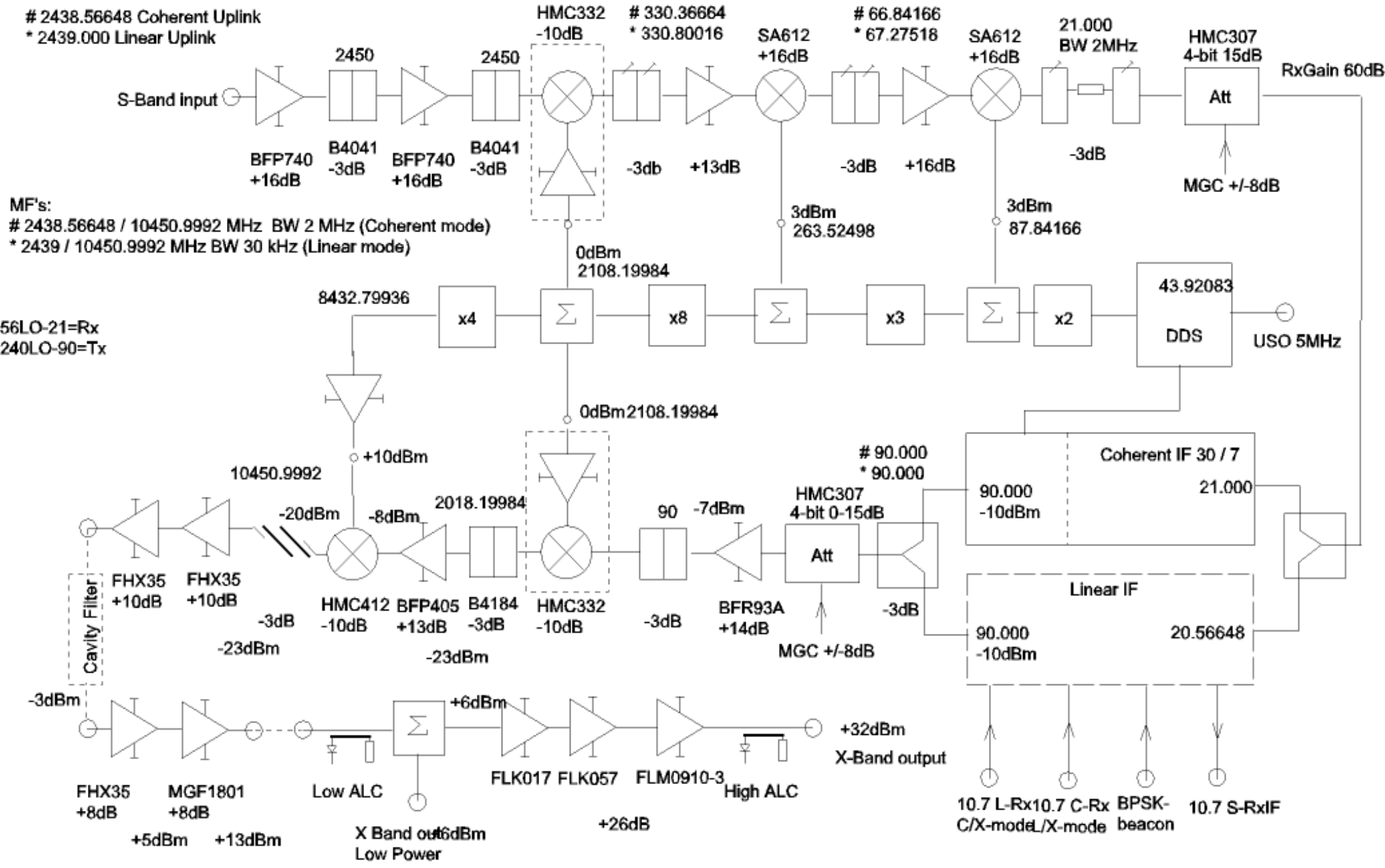
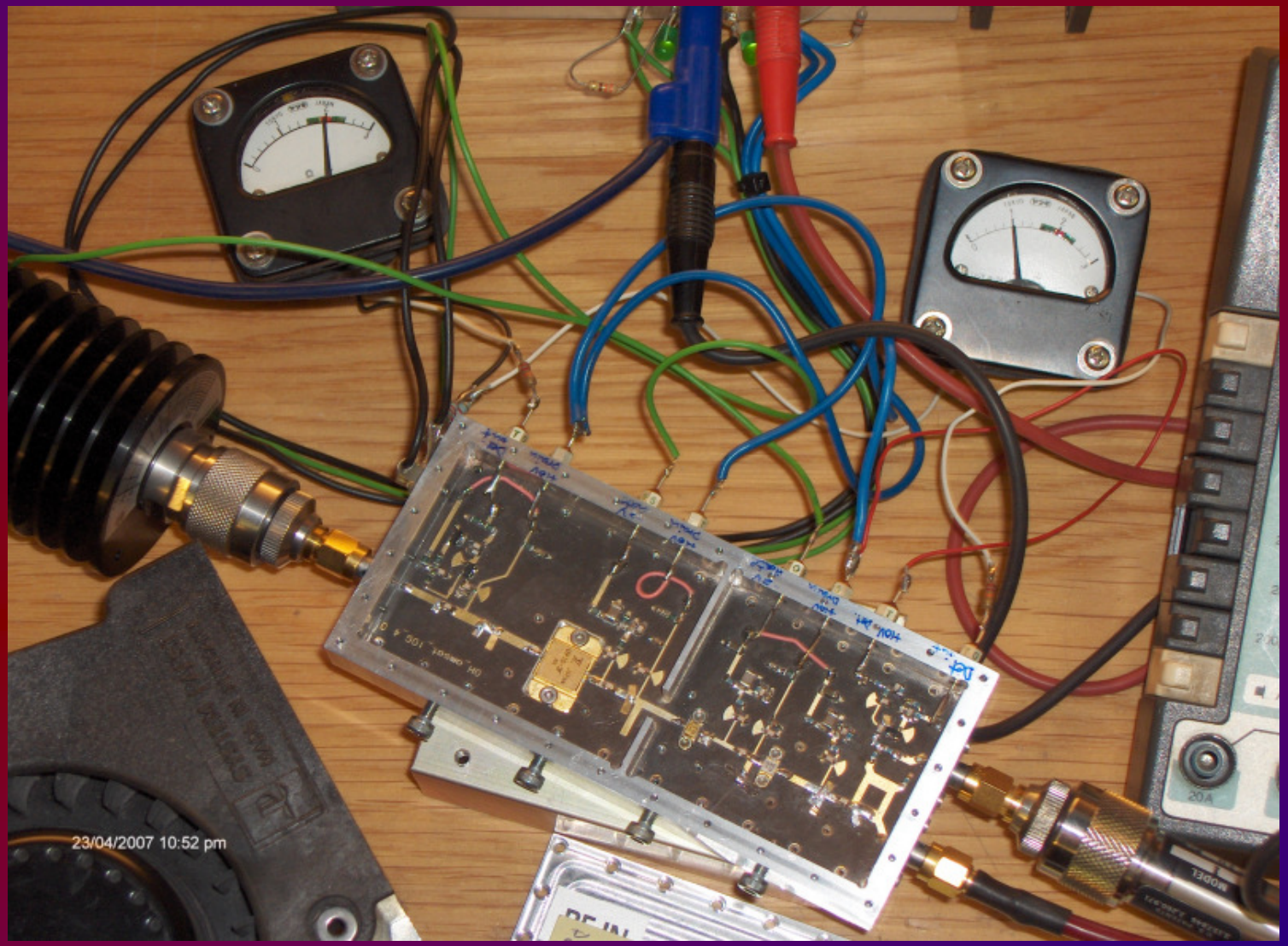
P3E S/X-Band Coherent Transponder ver 8.7.2006



Linear Mode: 3 Watt PEP SSPA flight model design
P5-A Mode: 1 mW PEP @ 10 GHz



RF frequencies for the Coherent Ranging/Linear transponder

43.92083 MHz (Reference DDS crystal)
100.73000 MHz (Linear IF Upconverter Crystal)
9.86648 MHz (Linear IF Downconverter Crystal)
10.73000 MHz (Beacon Crystal)

Linear Transponder Downlink Passband (-3 dB):
10451.011 - 10451.049 MHz (Center: 10451.030 MHz)

Linear Transponder Uplink Passband Center Frequency:
2441.000 MHz (Bandwidth 38 kHz)

Coherent Ranging Transponder Downlink Center Frequency:
10451.000 MHz

Coherent Ranging Transponder Uplink Center Frequency:
2438.566 MHz (Bandwidth approx. 2 MHz)

SDX und IHU-3 Meeting in Marburg

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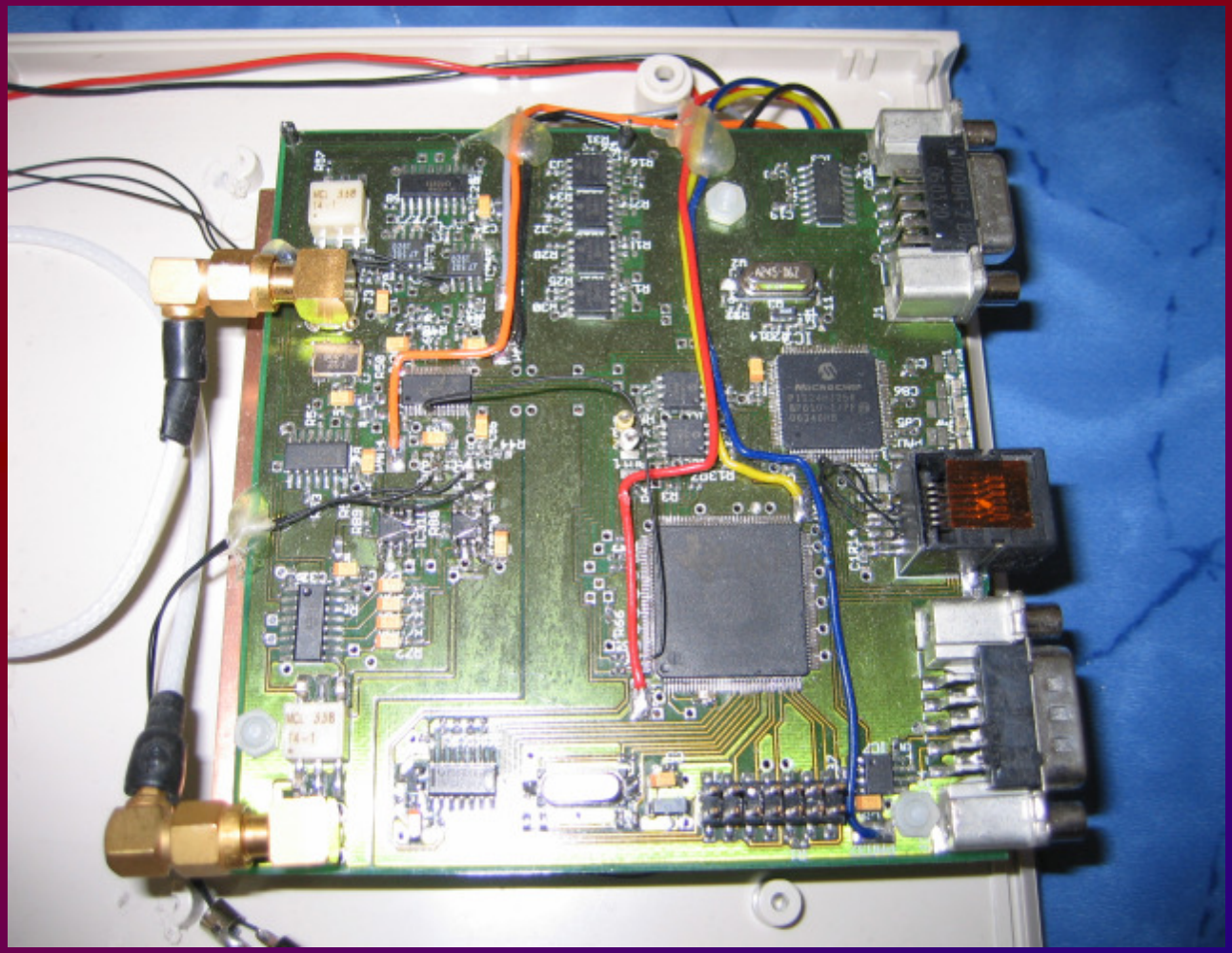
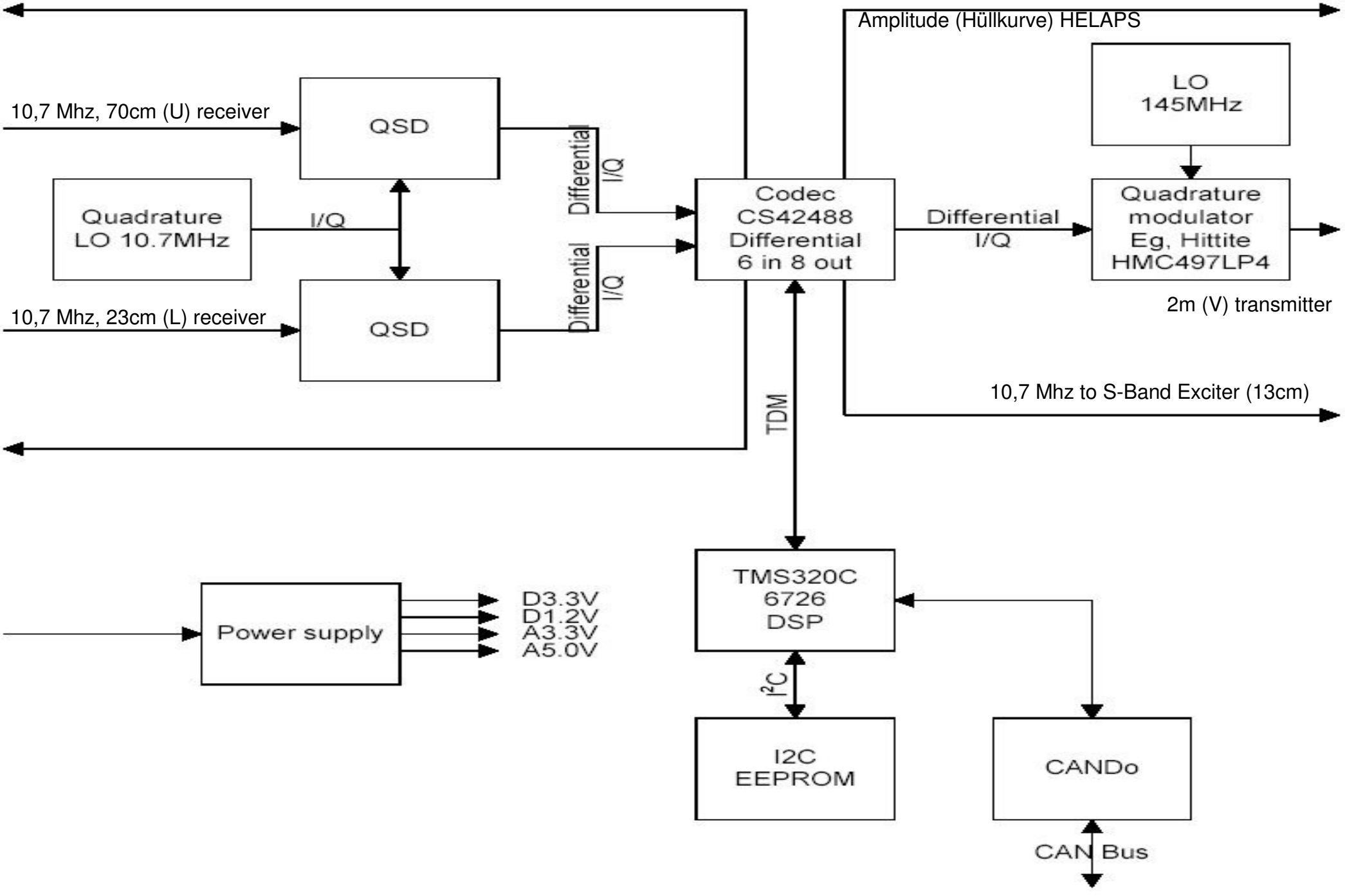
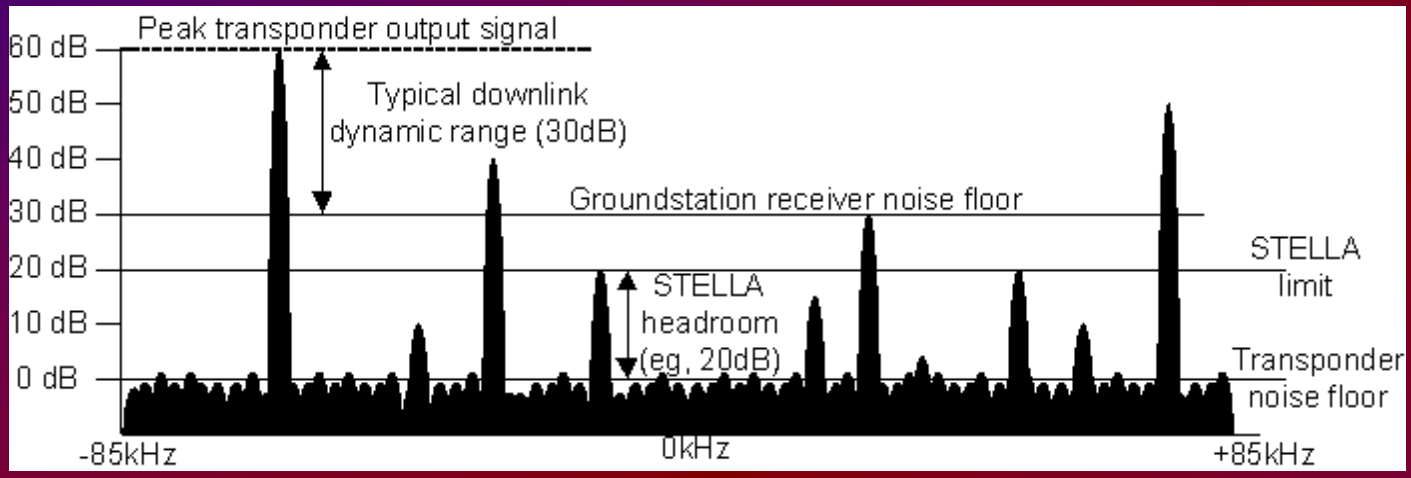
First working prototype for the UV-Transponder SDX - Module E06

Howard Long
G6LVB



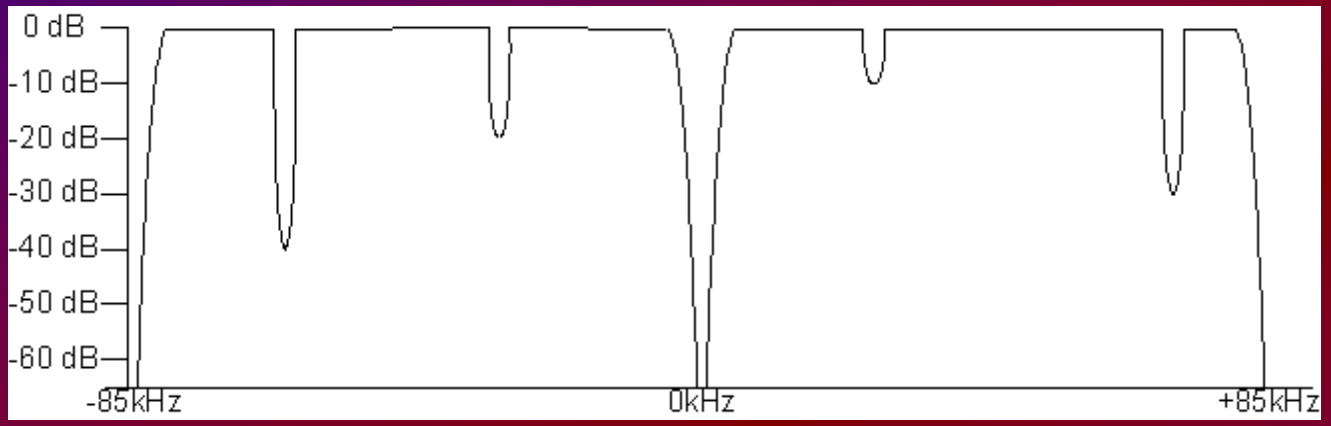

Amplitude (Hüllkurve) HELAPS
LO
145MHz
10,7 Mhz, 70cm (U) receiver
QSD
Differential
I/Q
Quadrature
LO 10.7MHz
I/Q
Codec
CS42488
Differential
6 in 8 out
Differential
I/Q
Quadrature
modulator
Eg, Hittite
HMC497LP4
2m (V) transmitter
10,7 Mhz, 23cm (L) receiver
QSD
Differential
I/Q
10,7 Mhz to S-Band Exciter (13cm)
TDM
TMS320C
6726
DSP
Power supply
D3.3V
D1.2V
A3.3V
A5.0V
I²C
I2C
EEPROM
CANDo
CAN Bus

Example transponder passband signals



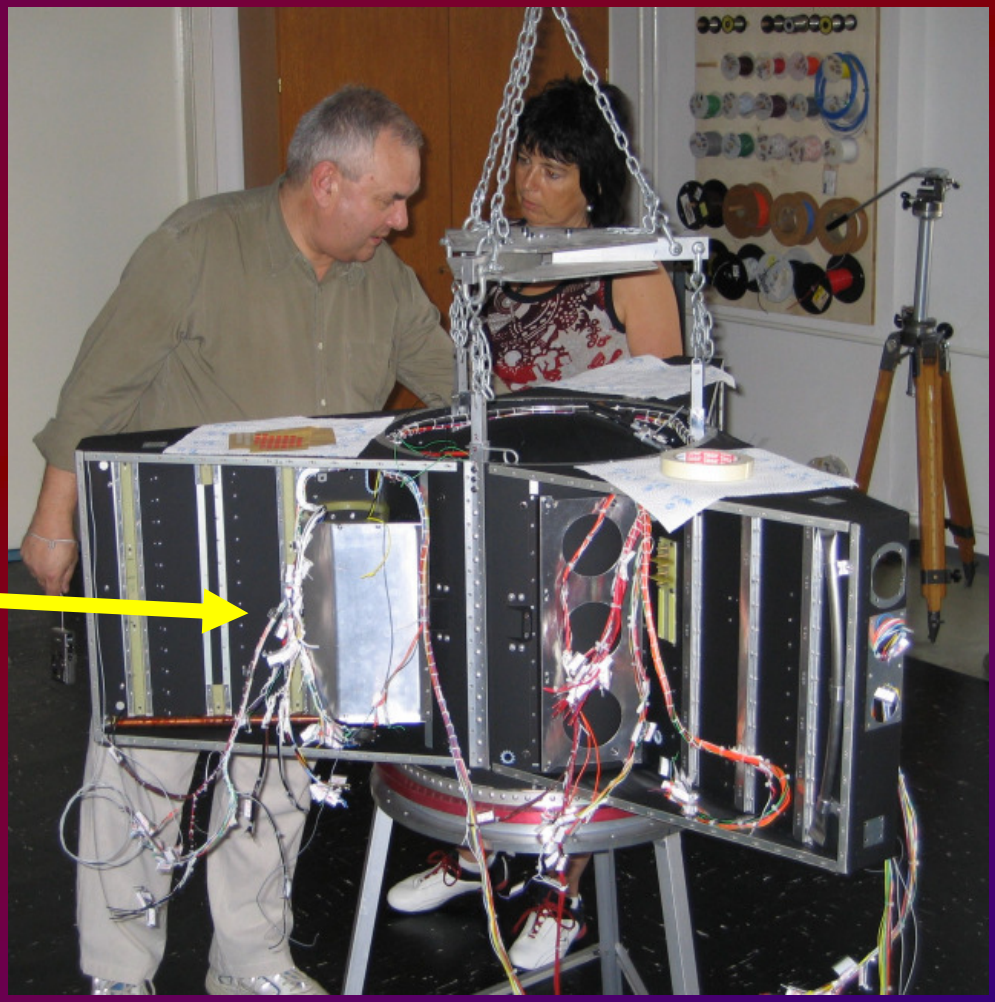
Reception of passband at groundstation after traditional transponder AGC suppression

Frequency response generated automatically by STELLA

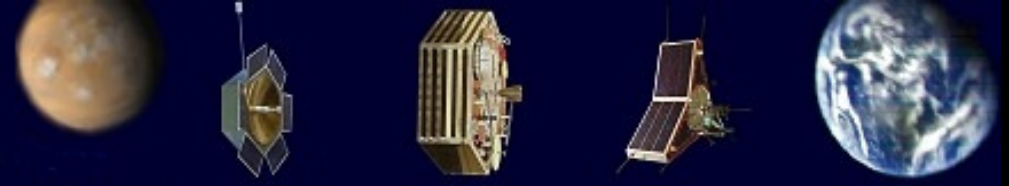


Resulting reception at groundstation with STELLA transponder

- Wiring Harness



Fuel tank is mounted and wiring harness installed..



CAN-DO

- Initial design idea: Peter Gülzow, DB2OS

- CAN-DO Team: Bdale Garbee, Lyle Johnson, Chuck Green, Stephen Moraco, Tilman Glötzner and others..

- Project initiated and sponsored by AMSAT-DL, co-sponsored by AMSAT-NA

- 100 Units to be build for P3-E, P5-A and EAGLE

- Successfully passed Radiation testing with Cobalt60 source and Protons

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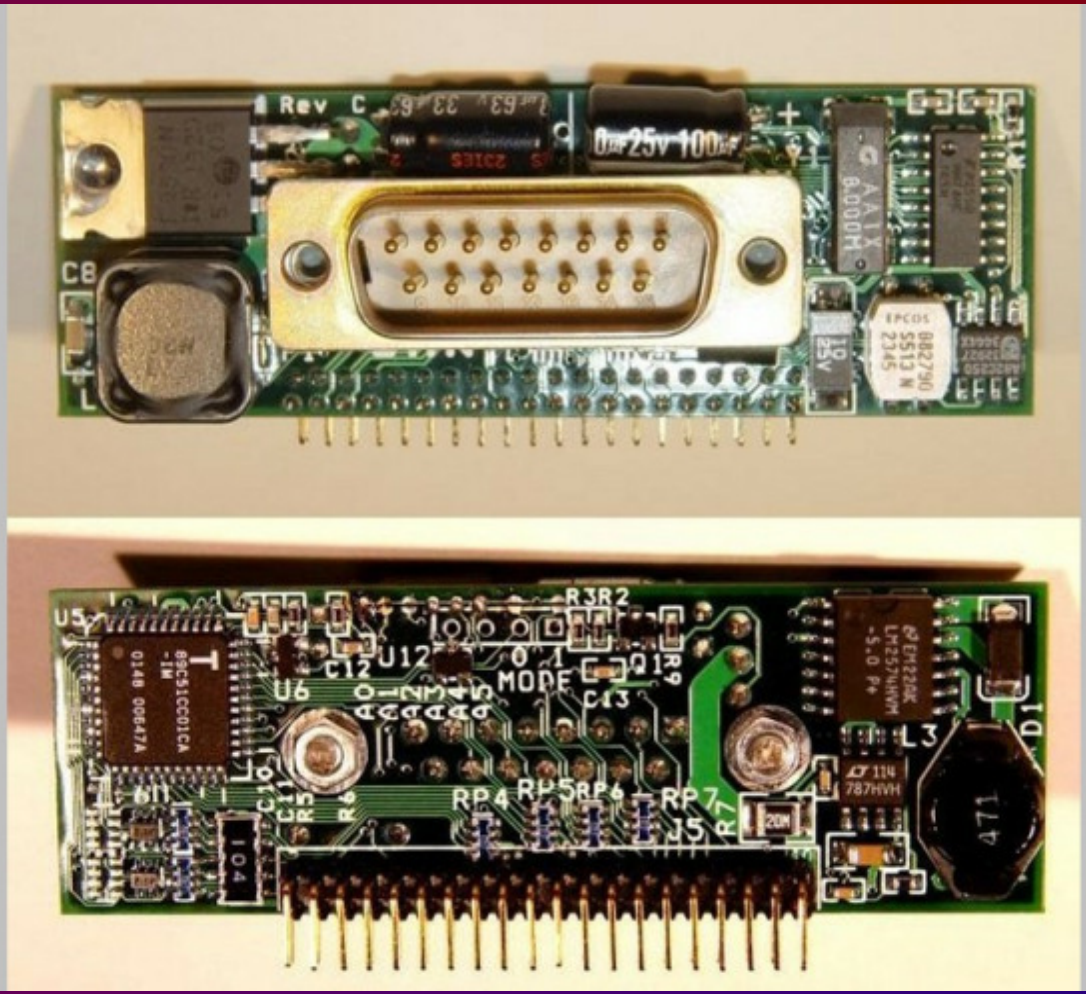
CAN-DO

- T89C51CC01 microcontroller
- 8051 architecture including CAN, RAM, Flash, ADC, PIO
- max. 64 CAN-DO modules on the bus
- 5 user ADC inputs
- 1 Power switch with current sensor
- 1 Temperature sensor
- 12 digital outputs and 8 digital inputs in Normal mode
- 63 digital outputs and 64 digital inputs in MUX mode



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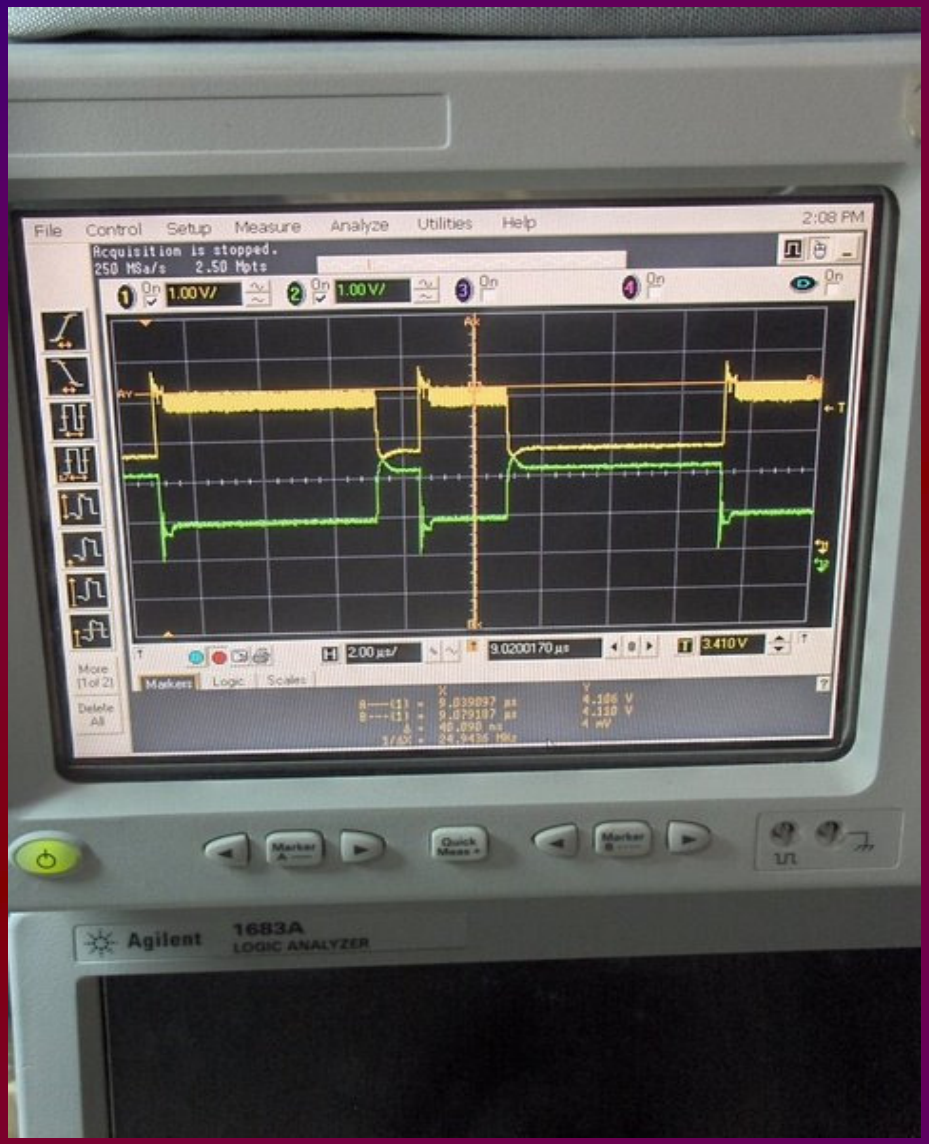
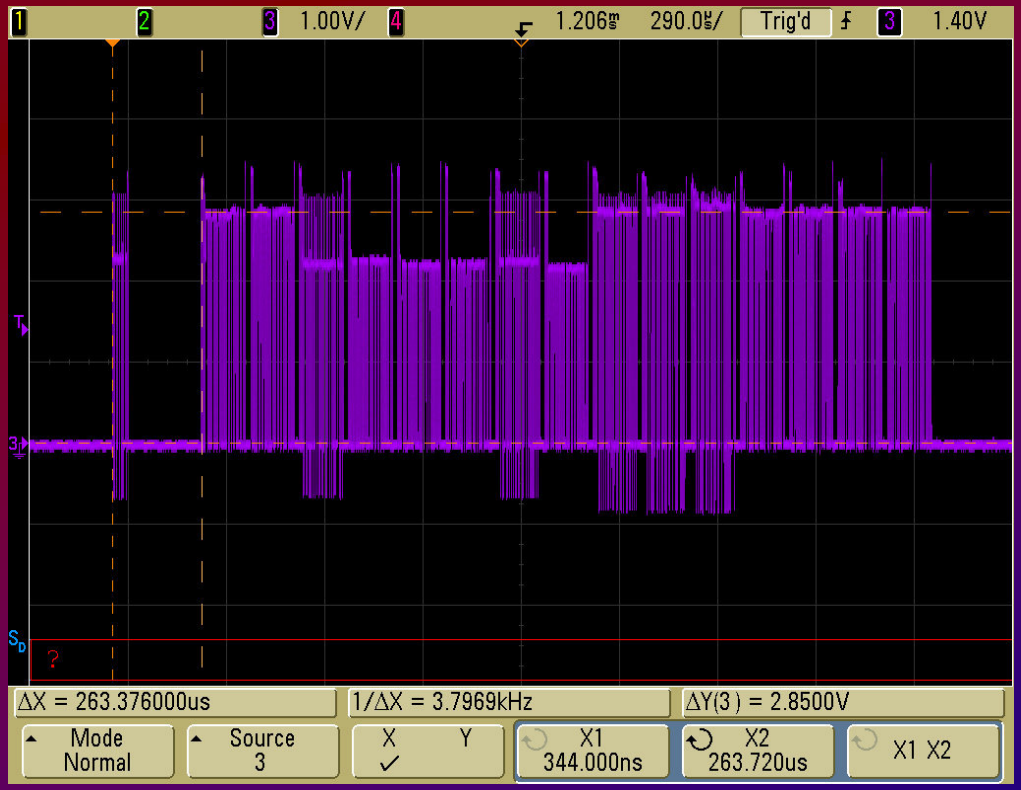
CAN-DO

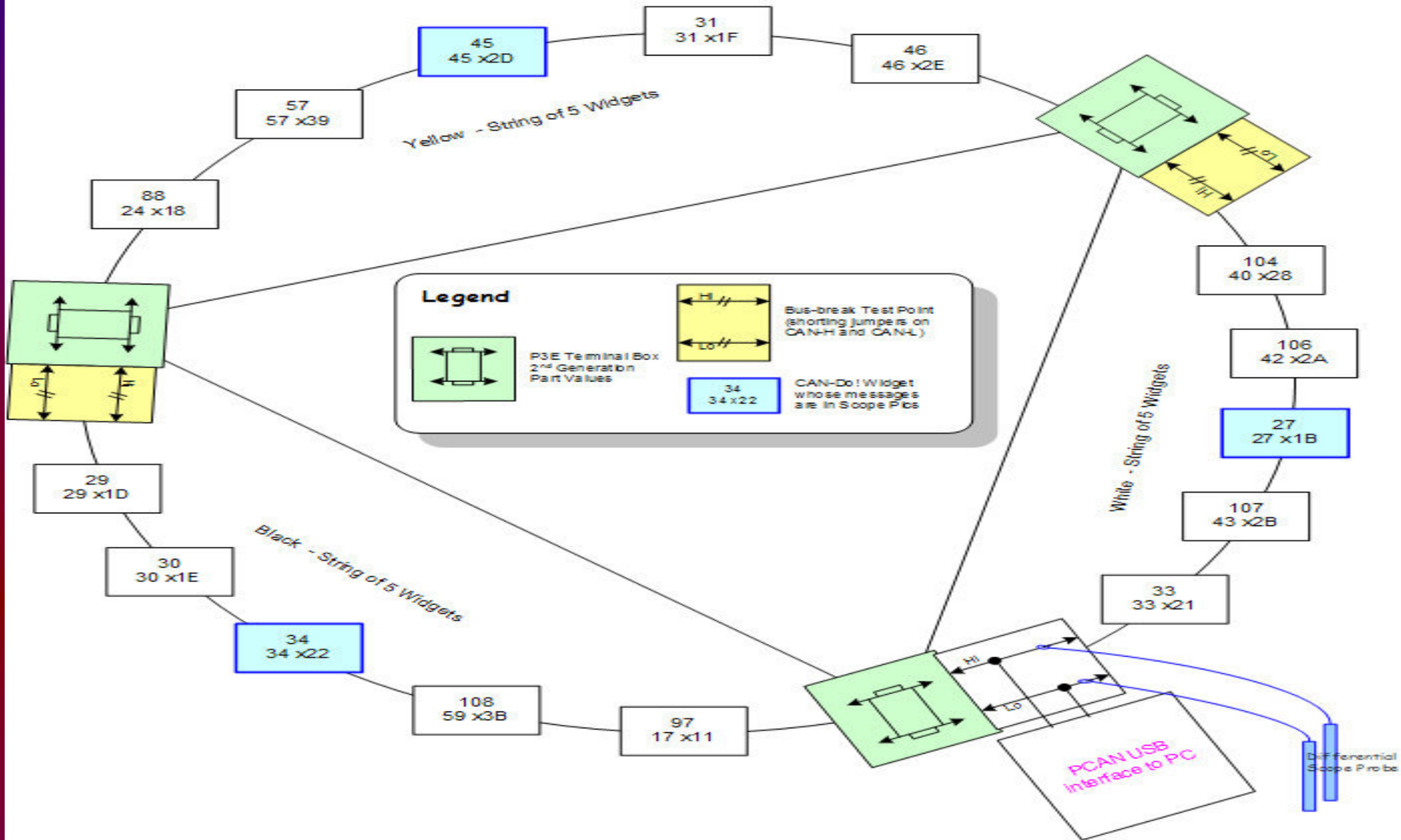
Stephen Moraco
KC0FTQ

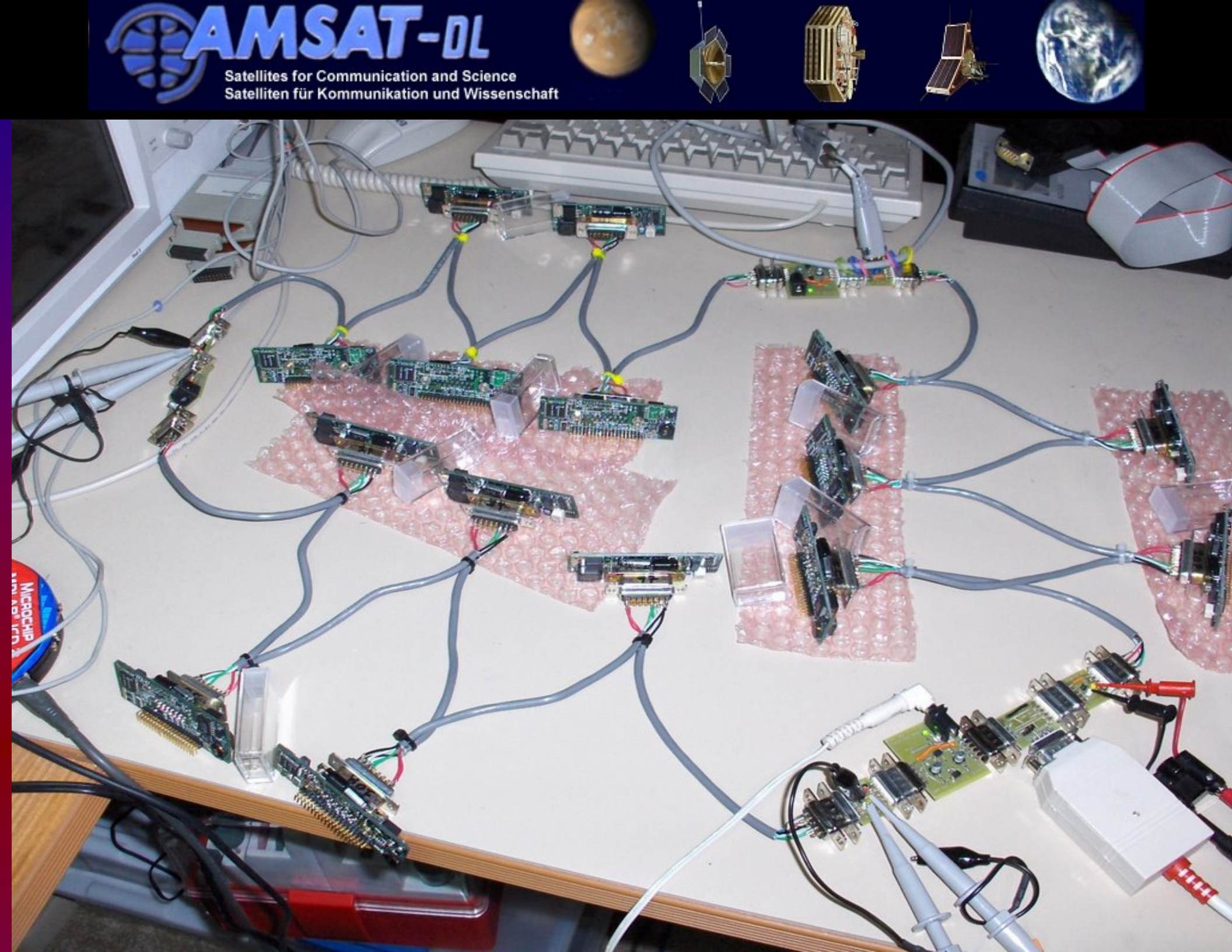




P3ECAN Ring Topology - Test Setup

Testing on KCOFTQ bench - 1 Feb 2007

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IHU-3

- Turbo Code licensed by France Telecom to AMSAT-DL for non-commercial usage on P3-E and P5-A

- first prototype software implemented and is currently ported to the IHU-3

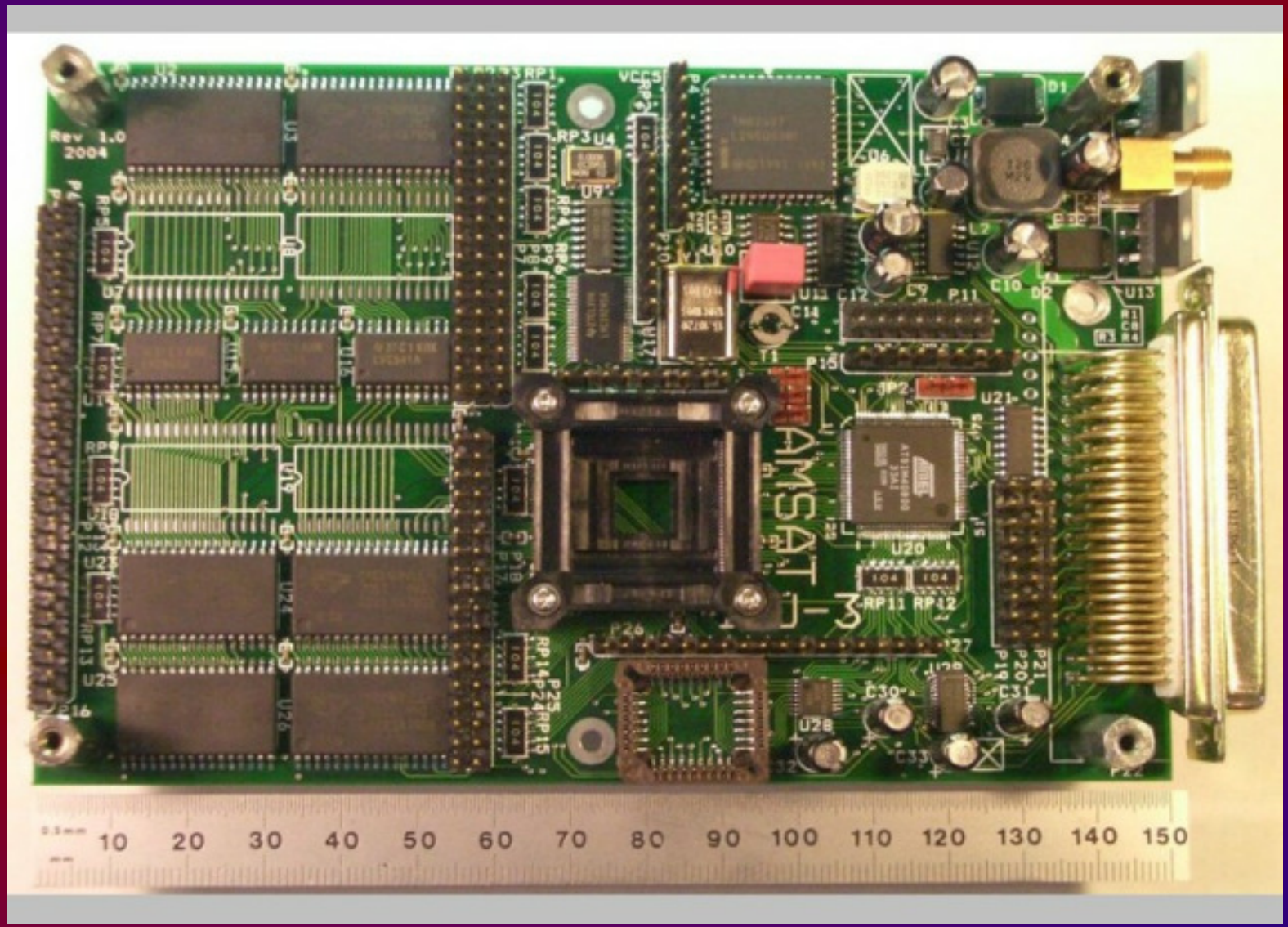
- ARM7TDMI-based CPU from ATMEL running IPS

- reference design for P3-E and P5-A will be used on future missions (Eagle, P3-F)

IHU-3

- CAN-Bus Interface running at 800 Kbit/s
- Lo-Speed Telemetry (~ max. 400 Bit/s BPSK or 800 Bit/s NRZ)
- Hi-Speed Telemetry (~ max. 50...100 Kbit/s)
- Software FEC using Reed-Solomon, Viterbi and TurboCode
- 128 or 512 Kbyte EDAC RAM
- 8...16 MB RAM (no EDAC)
- 128 Kbyte FLASH
- ADC/DAC for SDR
- running IPS software

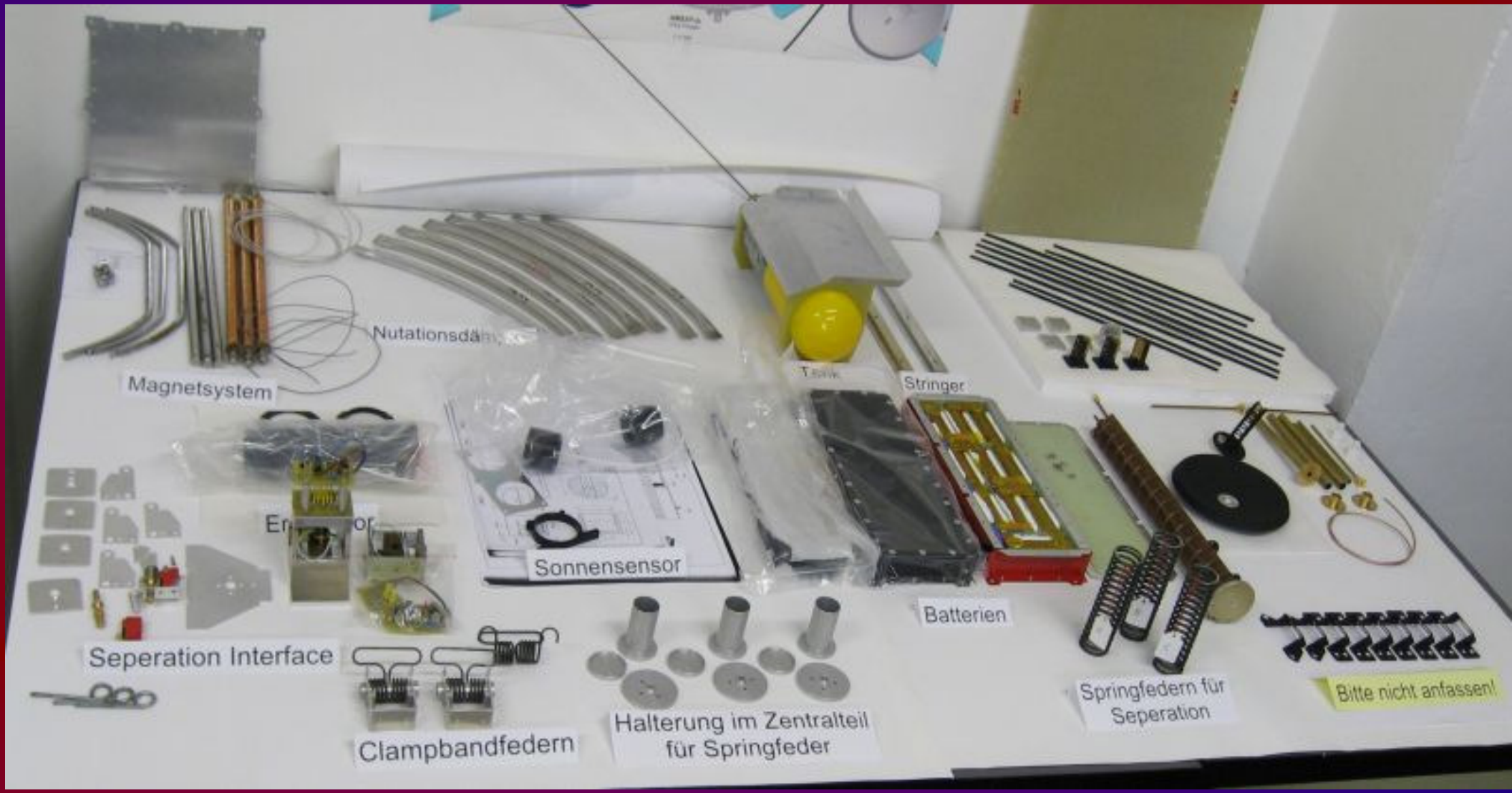
IHU-3

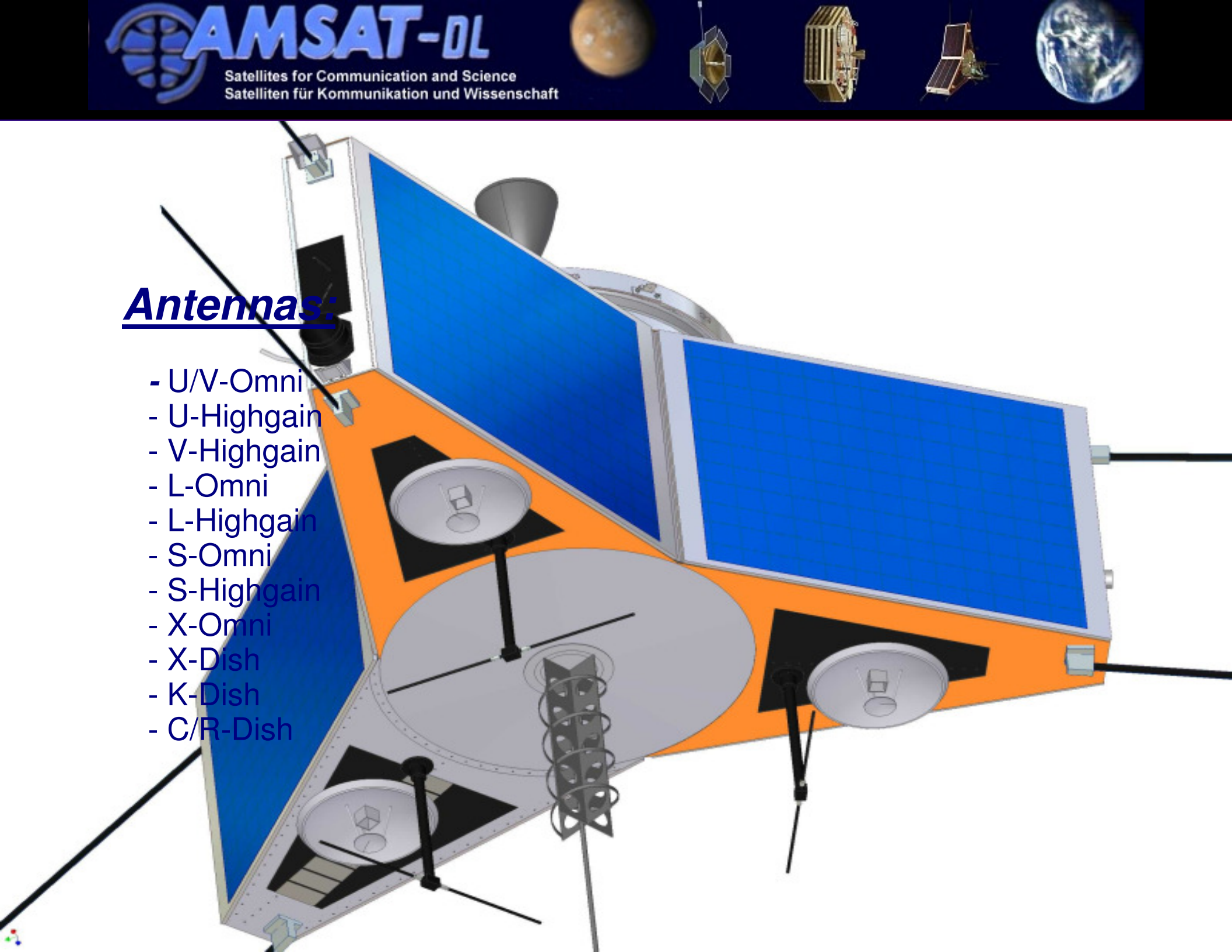

Rev 1.0
2004
AMSAT I-3
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Clampband

Clampband

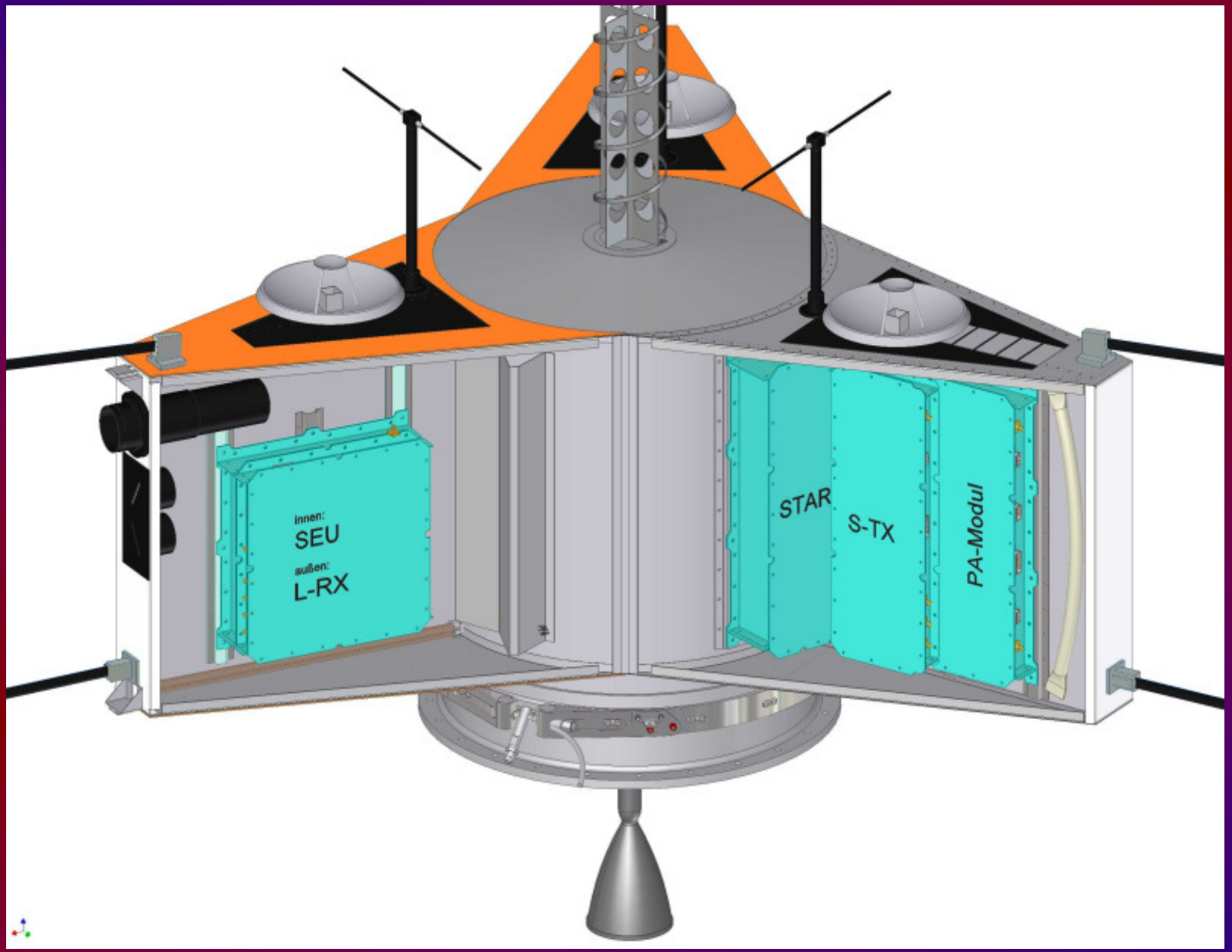
P3-E mechanically ready

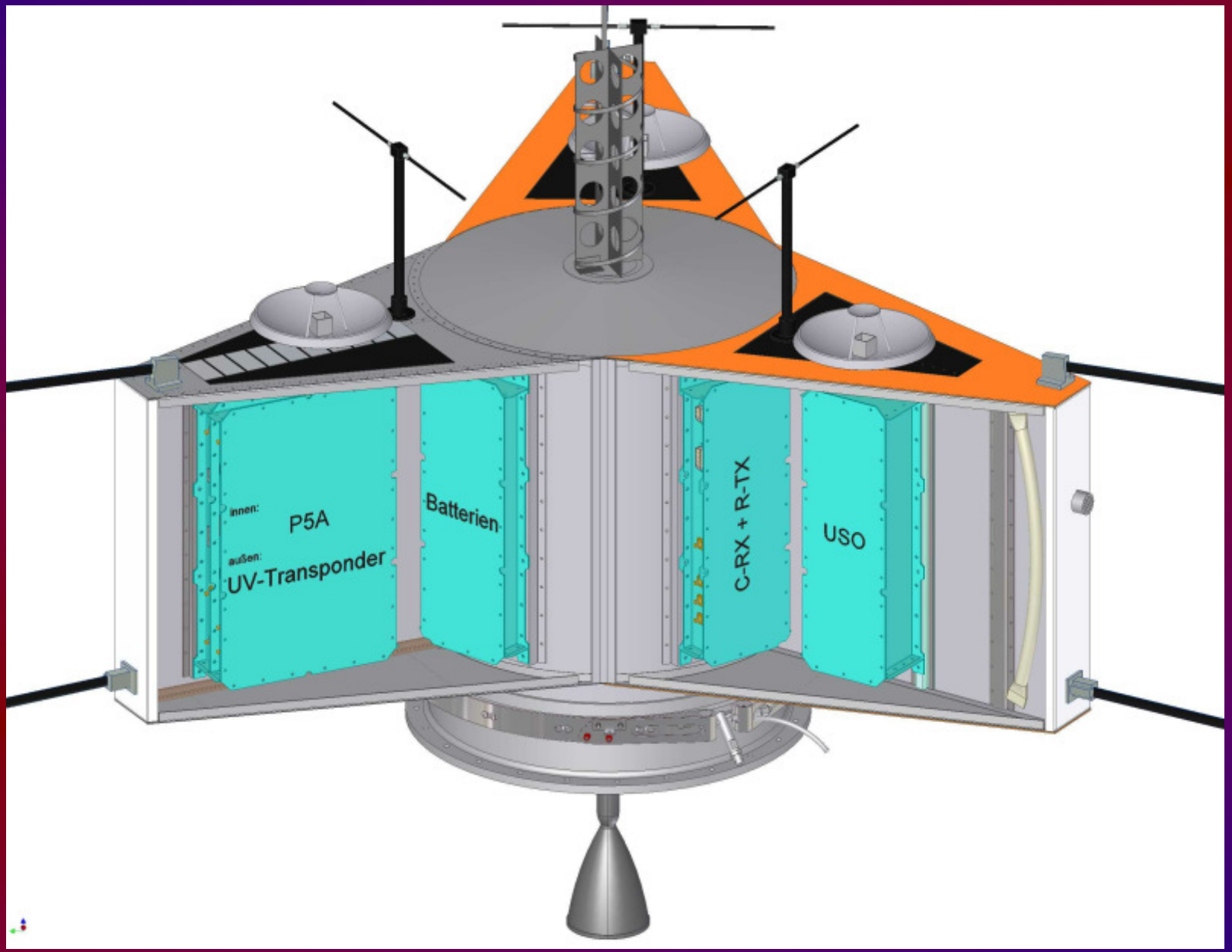


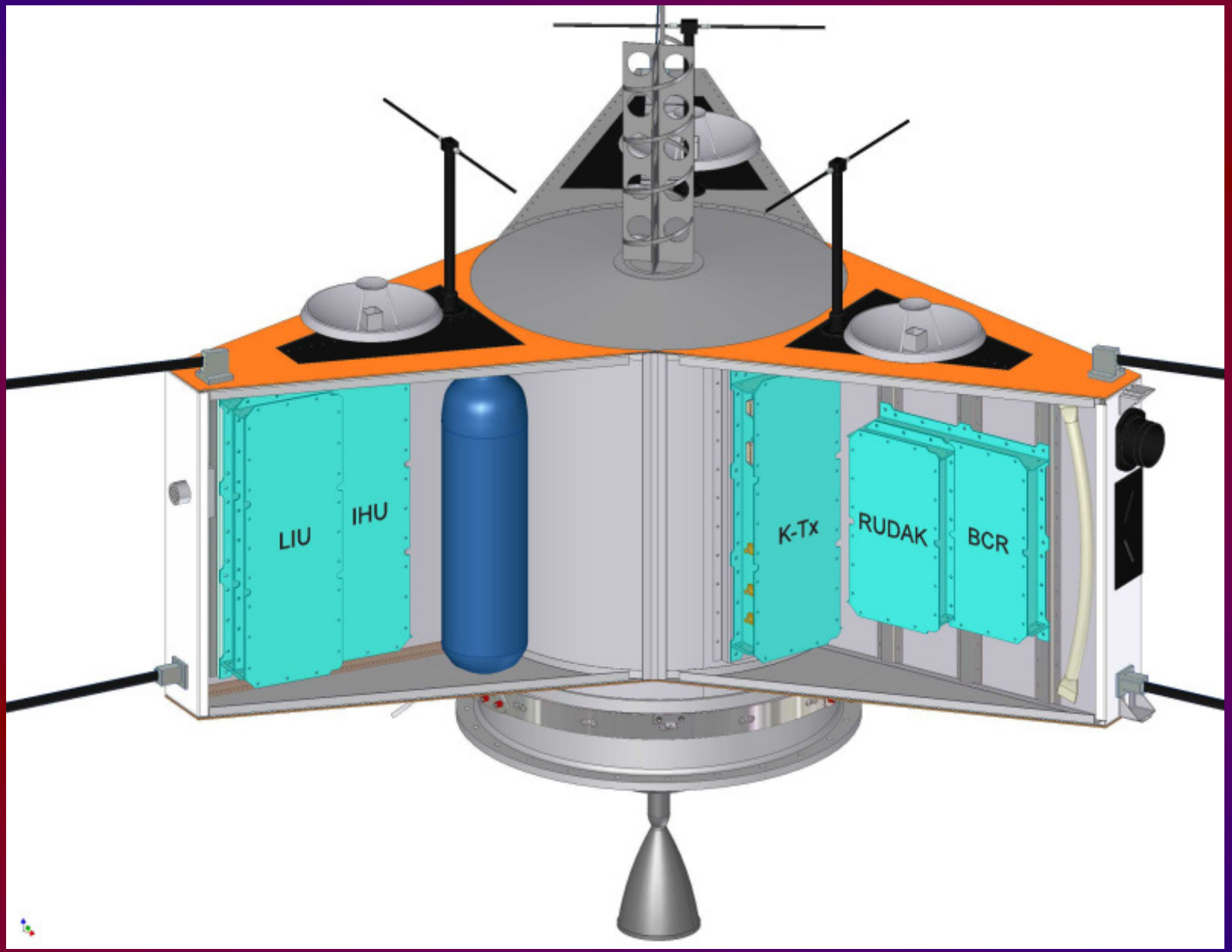


Antennas:

- U/V-Omni
- U-Highgain
- V-Highgain
- L-Omni
- L-Highgain
- S-Omni
- S-Highgain
- X-Omni
- X-Dish
- K-Dish
- C/R-Dish


innen:
SEU
außen:
L-RX
STAR
S-TX
PA-Modul


innen:
P5A
außen:
UV-Transponder
Batterien
C-RX + R-TX
USO


LIU
IHU
K-Tx
RUDAK
BCR

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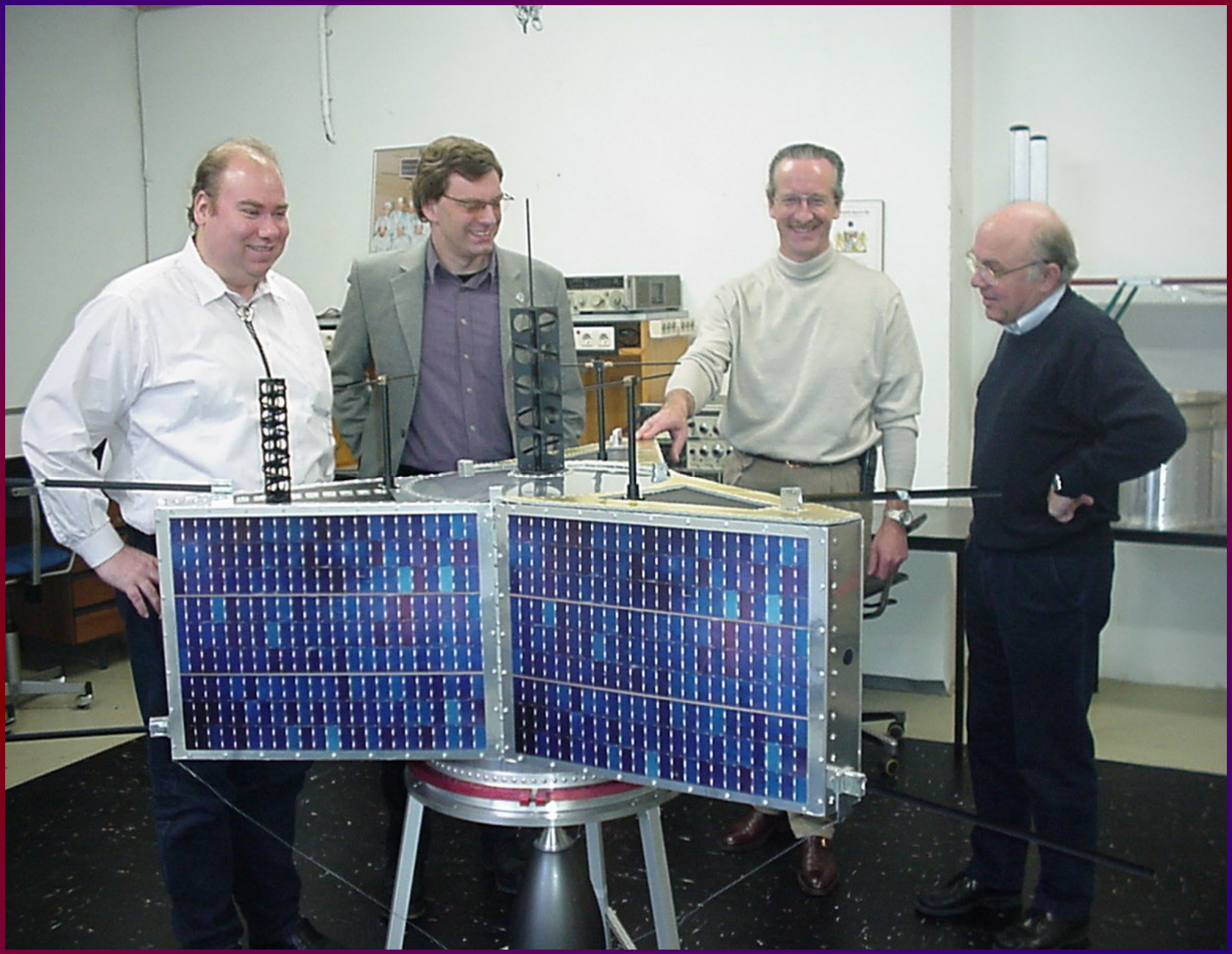

P3-Express
to launch in the SBS

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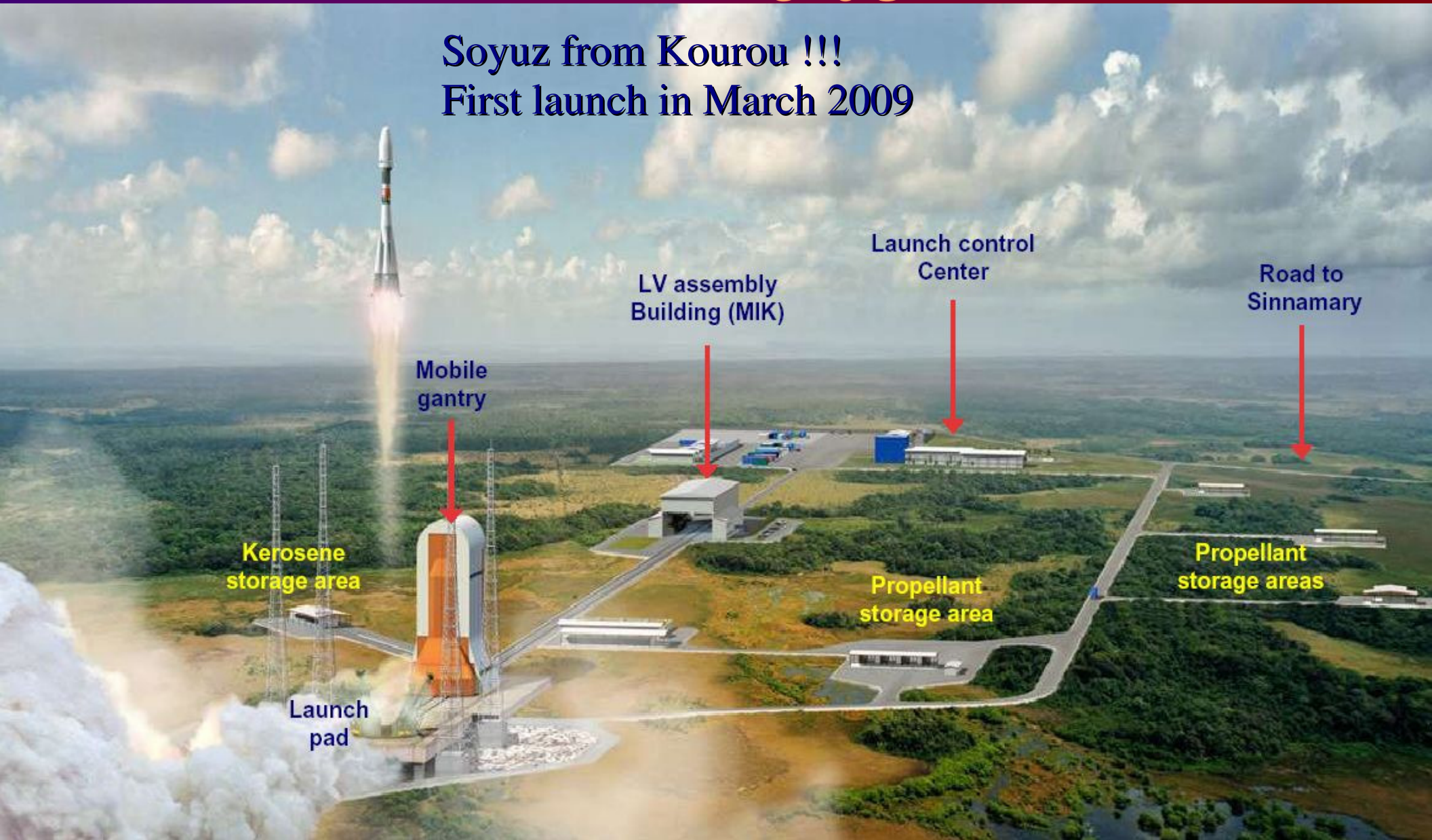
Launches Speak Louder Than Words



The main layout of the ELS is on schedule
Launch control Center area
Propellant storage
Propellant storage
MIK area
Kerosene storage
Railway
Propellant storage
Launch pad area

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Arianespace Customers Seminar Kourou 2006

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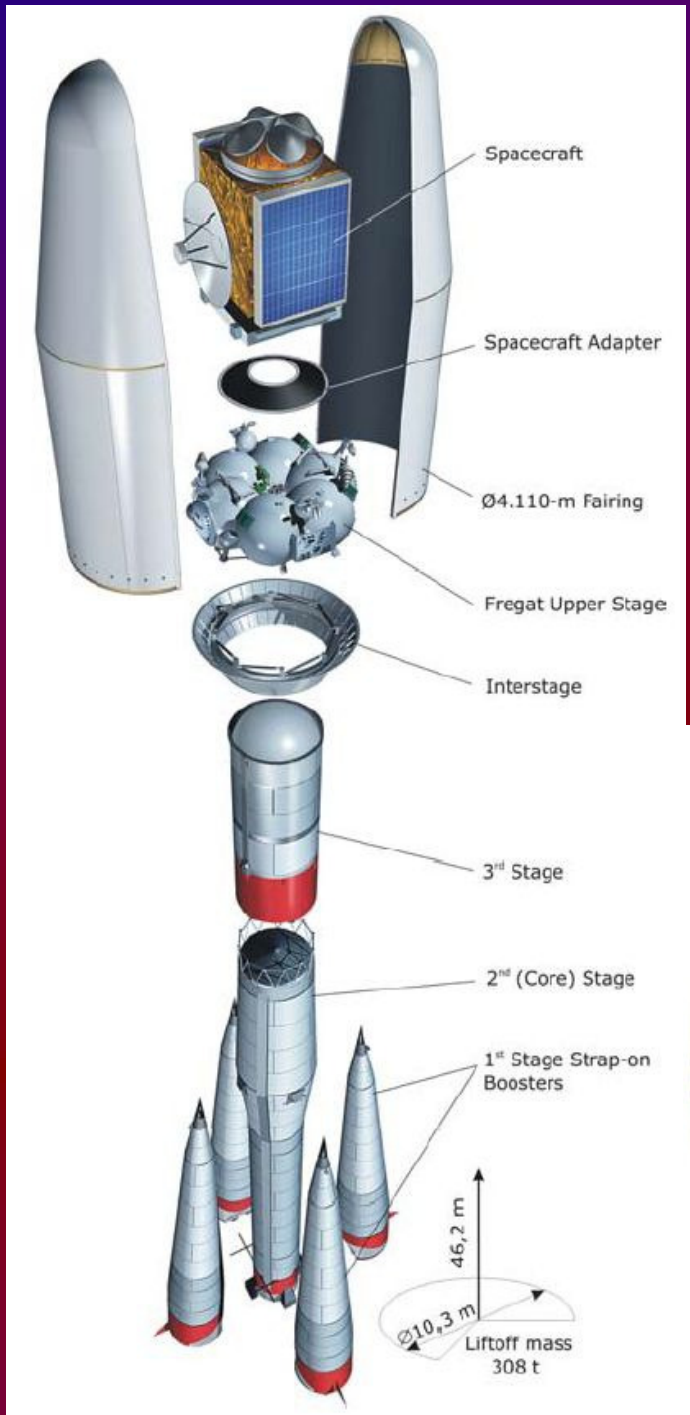

- SOYUZ

- launch of Sputnik in 1957
- more than 1,700 missions performed to date
- Soyuz 2-1-a version will be 2,700 kg to GTO
- Soyuz 2-1-b version will be 3,000 kg to GTO
- Propellant: LOX and Kerosene

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Soyuz Customers Seminar Samara Space Center (TsSKB-Progress) June 2007

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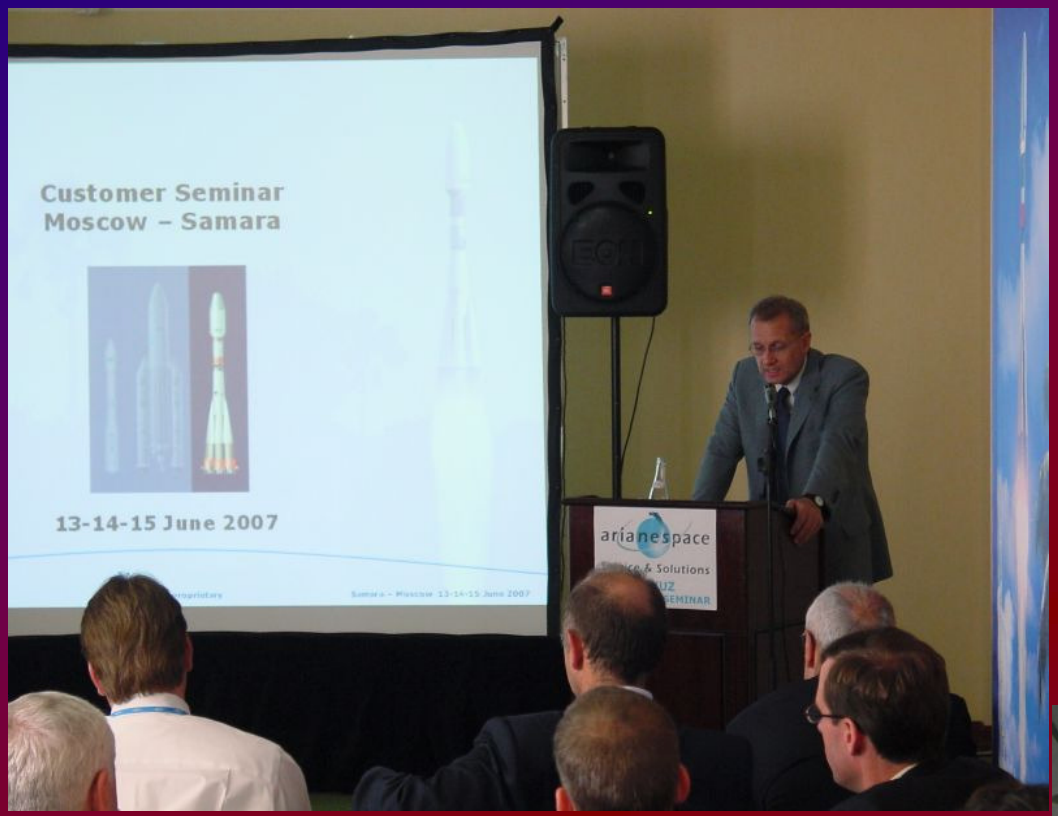
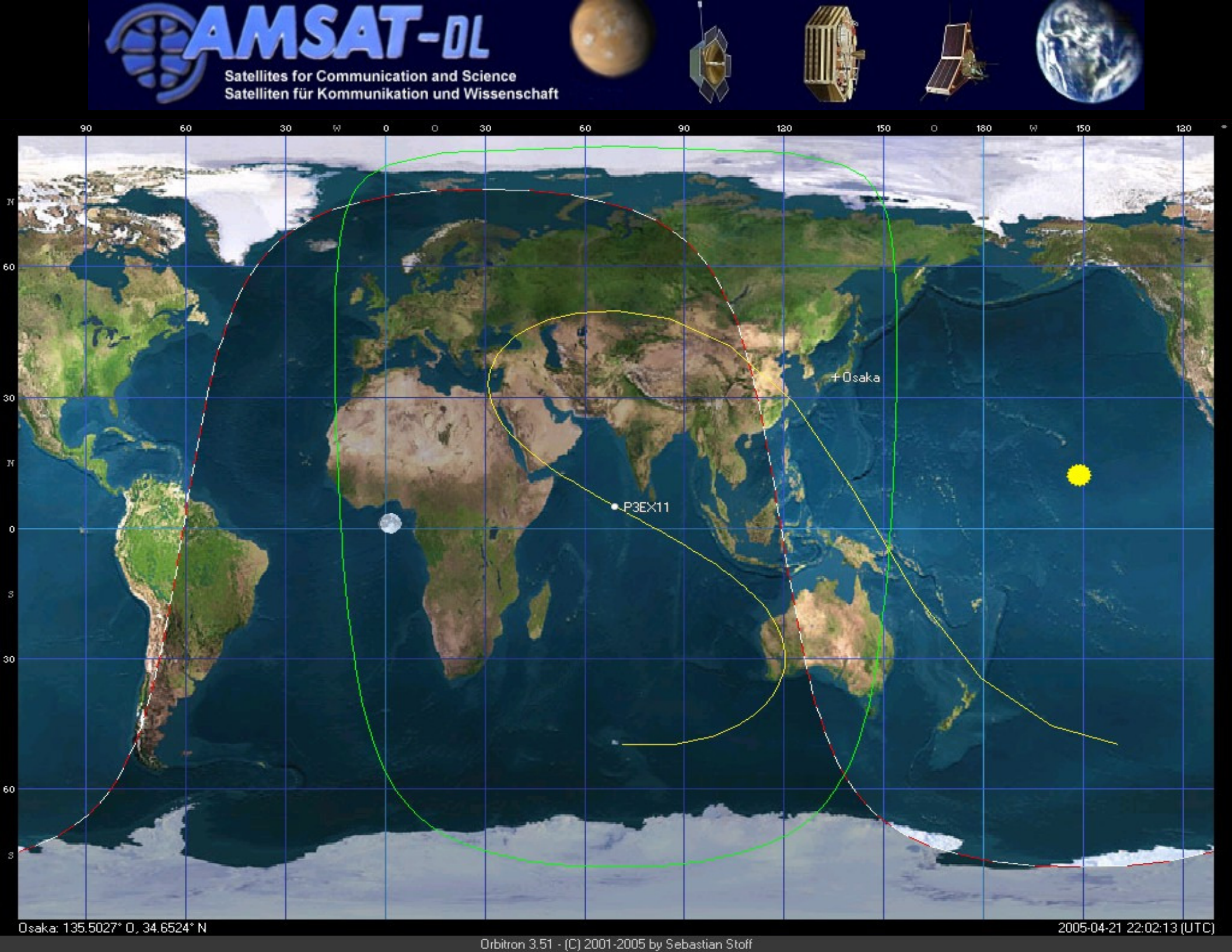


Samara – Moscow – Hannover - Paris

... busy weeks for P3-E and P5-A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Satellites for Communication and Science
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90
60
30
W
0
O
30
60
90
120
150
O
180
W
150
120
N
60
30
N
0
S
30
60
S
Osaka
P3EX11
Osaka: 135.5027° O, 34.6524° N
2005-04-21 22:02:13 (UTC)
Orbitron 3.51 - (C) 2001-2005 by Sebastian Stoff

P3E Time Schedule

2007

May	June	July	August	September	October	November	December
Manufacture of Flight Modules							
			Delivery of Flight Modules + Checkout				
					Electrical Integration		
							31.12.07 ZEL Closed!

2008

January	February	March	April	May	June	July	August	September	October	November
Thermal Vacuum Test + Vibration Test										
							Shipment to Launcher + Launcher Campaign			
										Launch

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Thermometer ?

or

http://www.p3e-satellite.de

- Buy Pixel..
- Put your logo here..
- make P3-E happen..
- fly to Kourou..
- see the launch !!

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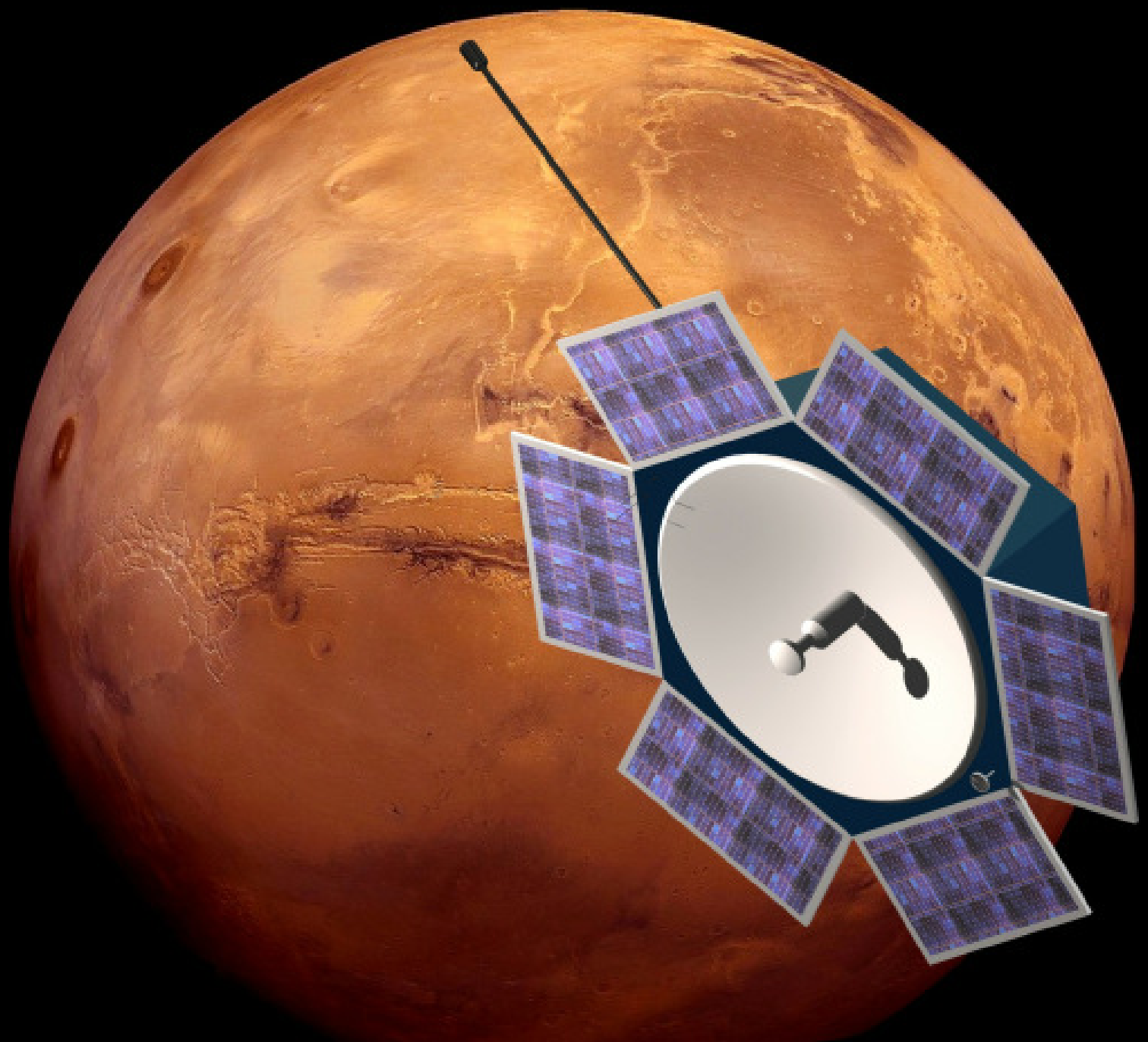
International Satellites
for Communication
and Science

GO Mars

with AMSAT-DL's
P5A-Mission



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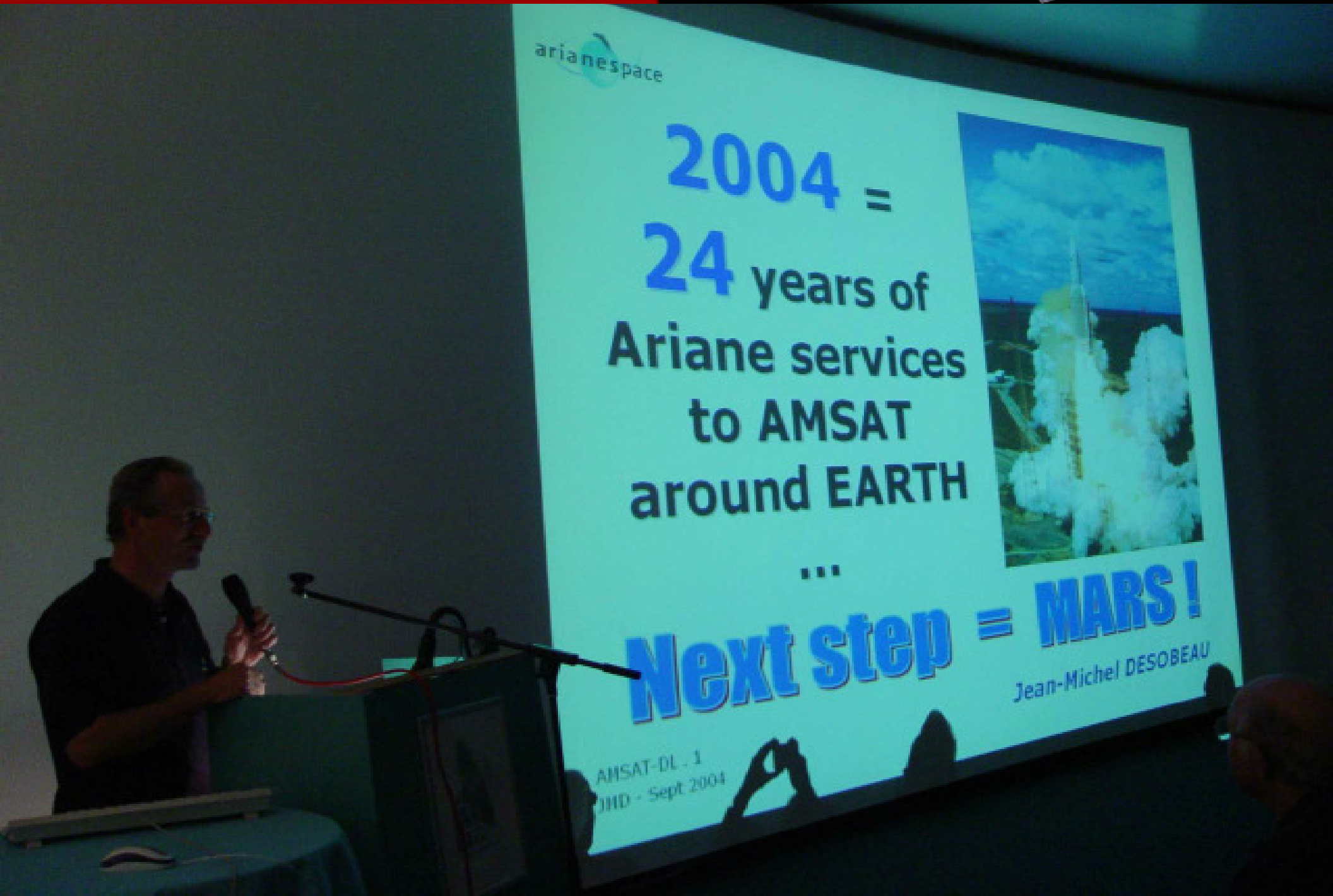
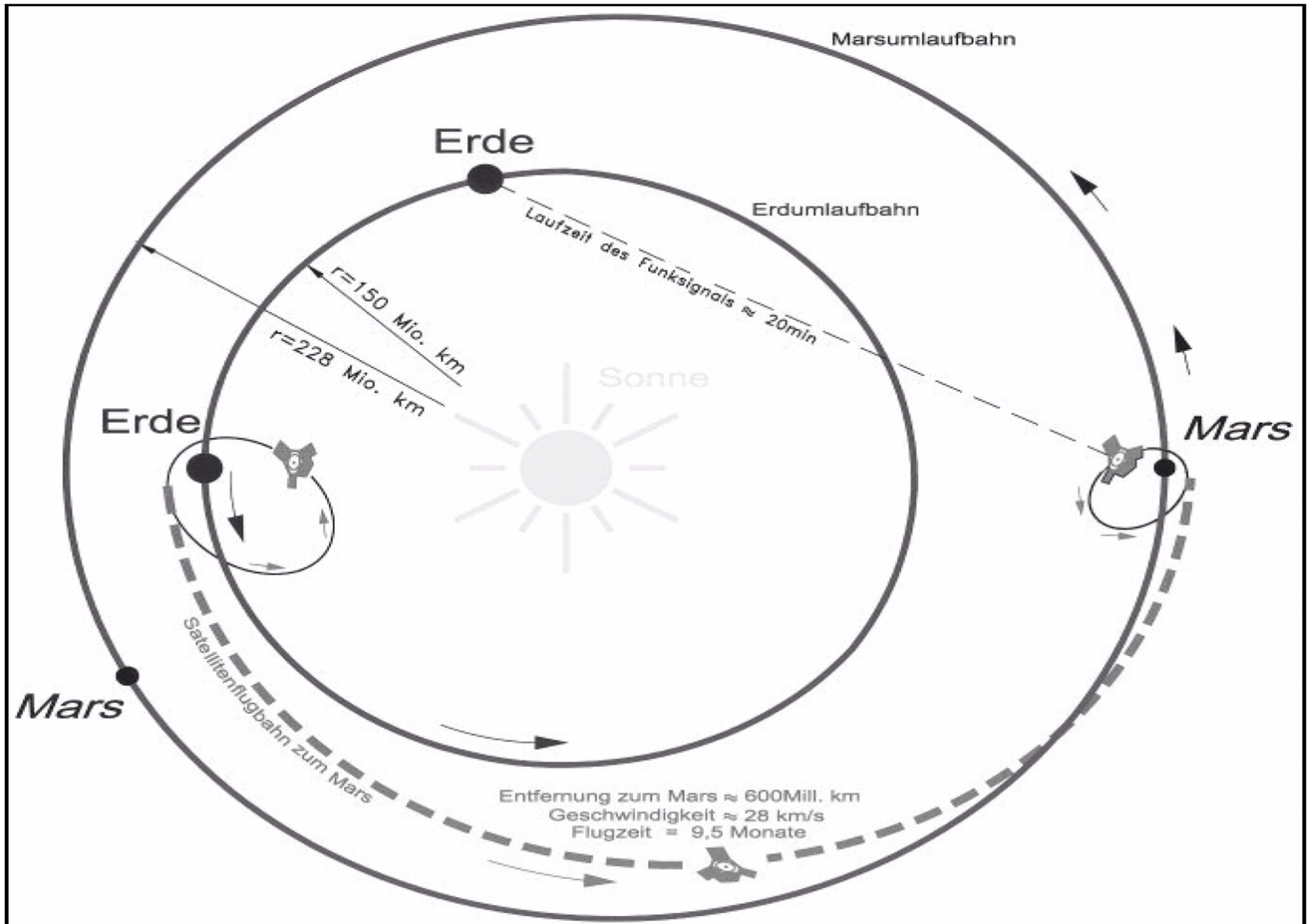
and Science

GO - Mars

with AMSAT-DL's
P5A-Mission





Geometry of Earth and Mars orbits and trajectory

20m dish Bochum (P5-A)

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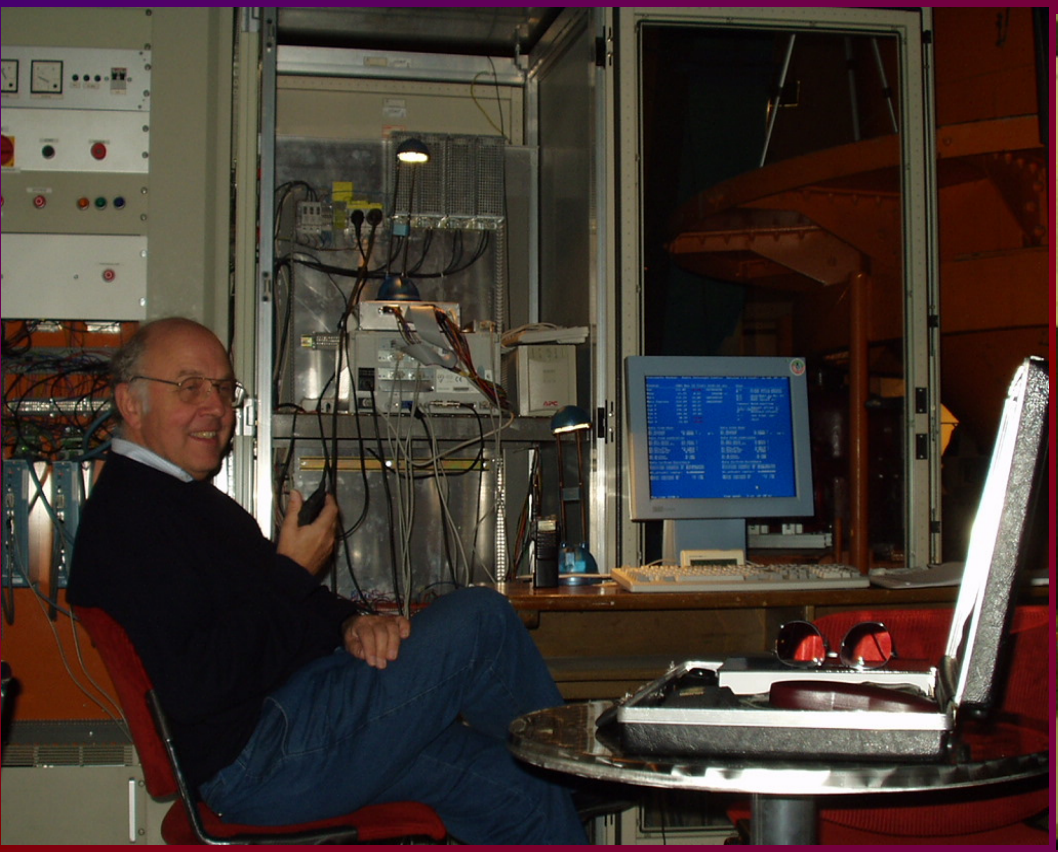
for Communication
and Science

GO Mars

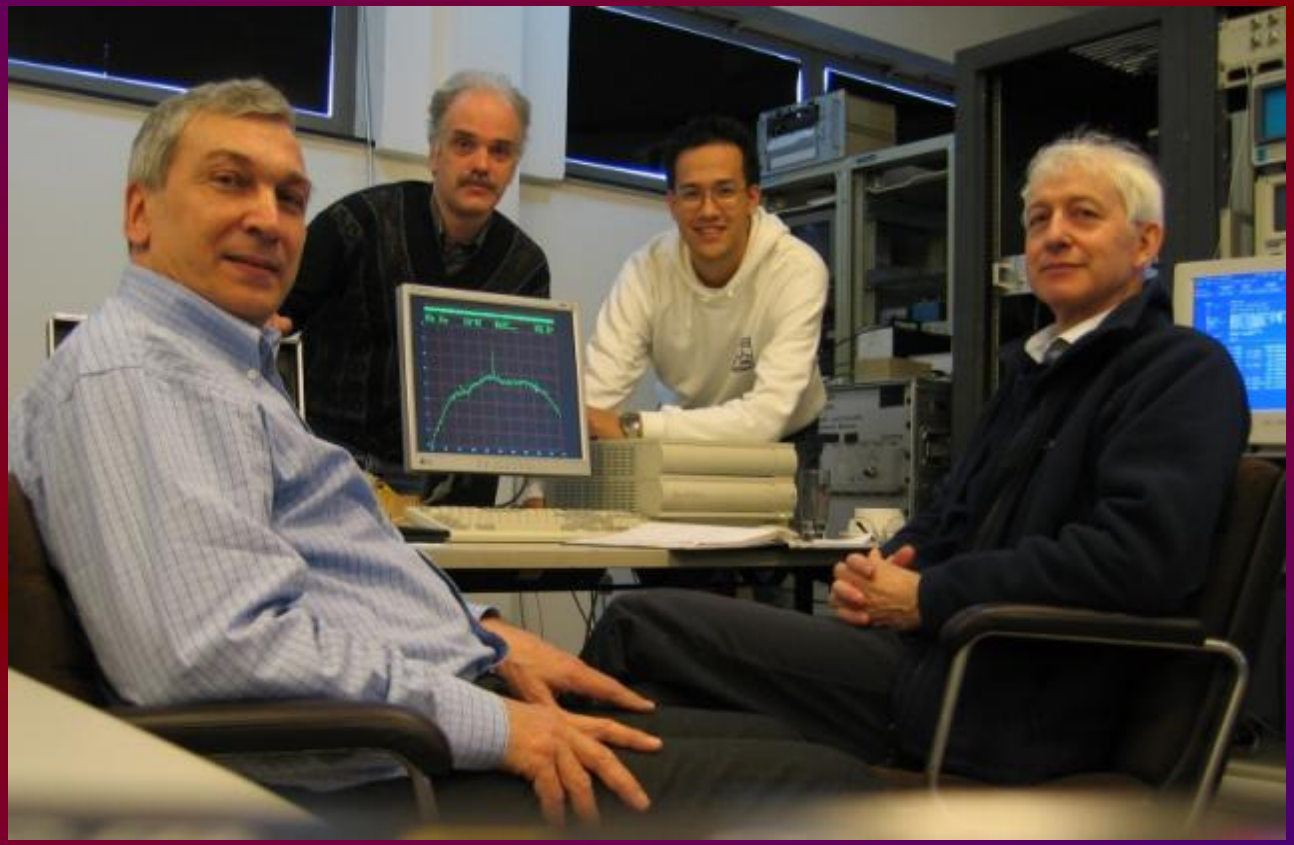
with AMSAT-DL's
P5A-Mission

20m dish Bochum (P5-A)



Space probe VOYAGER 1 successfully received (31.3.2006)

distance ~14.7 billion km



Freddy de Guchteneire ON6UG, Hartmut Paesler DL1YDD, Achim Vollhardt DH2VA/HB9DUN, James Miller G3RUH

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International Satellites for Communication and Science

GO Mars with AMSAT-DL's P5A-Mission

JPL Voyager Flight Team congratulates AMSAT-DL

Nobeyama Radio Observatory

Ø 45m
20-230 GHz

Ø 80cm
17+34 GHz
84 dishes

Ø 10m
80-230 GHz
6 dishes

http://www.amsat-dl.org/cms/

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and Science

GO Mars

with AMSAT-DL's
P5A-Mission

www.AMSAT-DL.org

www.p3e-satellite.org

www.ticket-to-mars.org